APPENDIX D: Environmental

LAKE WORTH INLET
Palm Beach Harbor

Appendix D: Environmental
Attachment 1: 404 (b) Evaluation

LAKE WORTH INLET
Palm Beach Harbor

SECTION 404(b) EVALUATION

I. Project Description

a. Location. Lake Worth Inlet and Palm Beach Harbor are on the Atlantic Coast of Florida, approximately 53 miles south of Ft. Pierce Harbor, and 71 miles north of Miami Harbor.

b. General Description. The U.S. Army Corps of Engineers (Corps), Jacksonville District, is proposing to widen and deepen the current Federal navigation channel at Lake Worth Inlet / Palm Beach Harbor. The proposed plan includes the following: addition of a new channel flare on the south side of the Entrance Channel, a widening of the Entrance Channel by either 40' or 60' to the north, widening of the Inner Harbor Cuts 1 and 2 to provide for a minimum channel width of 450', a 150' expansion of the Southern (Main) Turning Basin to the south, and an expansion of the Southern (Main) Turning Basin on the north side to remove a notch currently encroaching into the basin. The channel would be deepened to a project depth of 39 feet Mean Lower Low Water (MLLW) for the Inner Harbor and 41 feet MLLW for the Entrance Channel plus applicable allowances and overdepths discussed in the Engineering Appendix included in the integrated Feasibility Report and Environmental Impact Statement (FR/EIS).

In addition to the project improvements described above that are necessary to facilitate the safe and efficient navigation of the design vessel, there are other features needed to support the project. These features include North Jetty stabilization, reconfiguration of the advanced maintenance zones, reconfiguration of the settling basin, seagrass mitigation construction, and hardbottom mitigation construction as detailed in the integrated FR/EIS.

c. Authority and Purpose. See **Chapter 1** of the integrated FR/EIS.

d. General Description of Dredged Material

(1) General Characteristics of Material: Please see **Chapter 4.2** of the integrated FR/EIS for additional detail as well as **Figure 4-1** and **Table 4-1** in the integrated FR/EIS for a listing of material by location. Generally, the following material is expected within the project limits: sands, silty sands, and interfingering rock layers.

(2) Quantity of Material: The tentatively selected plan would dredge a total of approximately two million cubic yards of material. Please see **Chapter 4.2** of the integrated FR/EIS for additional detail.

(3) Source of Material: Dredged material would come from the Federal navigation channel for Lake Worth Inlet as well as the proposed widening and deeping locations shown in the reference map in **Chapter 4** of the integrated FR/EIS.

e. Description of the Proposed Discharge Site(s)

(1) Location. It is anticipated that all of the material to be excavated from the entrance channel up to Station 45+00 would be placed in nearshore placement area, located below mean high water line, with the exception of the amount which would be used to mitigate for seagrasses. The remainder of the material would be placed at the Palm

Beach Ocean Dredged Material Disposal Site (ODMDS). Please see also **Chapter 4.8** of the integrated FR/EIS.

(2) Size. Near shore quality sand would be placed in the near shore (below the MHW line) between DEP range monuments R-76 to R-79, used for mitigation, or placed in the designated ODMDS.

(3) Type of Site. Nearshore, ODMDS, or proposed mitigation site.

(4) Type(s) of Habitat. Nearshore consists of bare sand with no exposed hard bottom or resources within the footprint. ODMDS site is bare sand/silty substrate with no exposed hard bottom. Proposed mitigation sites consist of sandy/silty substrate within the inlet for seagrass mitigation, and nearshore sand substrate for hard bottom mitigation.

(5) Timing and Duration of Discharge. The exact timing of dredging operations is not known, although dredging activities are expected to occur in the winter months.

f. Description of Disposal Method. Disposal could be either from a pipeline via hydraulic dredging or clamshell dredge and transport barge.

II. Factual Determinations

a. Physical Substrate Determinations

(1) Substrate Elevation and Slope: The material would be placed below mean low water to elevation -16.

(2) Sediment Type. The material to be disposed in the nearshore would be silty sand in nature. Rock and material not suitable for nearshore placement would be disposed of at the ODMDS.

(3) Dredged Material Movement: Material would settle and be moved to downdrift beaches by wave action if placed in nearshore. It is expected the material would remain in place if used for mitigation. Material deposited in the ODMDS would remain within the confines of the ODMDS.

(4) Physical Effects on Benthos: Some benthic organisms that are not mobile may be may be covered by the nearshore placement and/or the mitigation site material. Recolonization soon after project completion is expected to replace those organisms that do not survive project construction. It is anticipated that no long-term adverse impacts would occur.

(5) Other Effects: NA

(6) Actions Taken to Minimize Impacts: BMPs and other benthic protection measures have been coordinated with the resource agencies to minimize impacts

b. Water Circulation. Fluctuation and Salinity Determinations

(1) Water column: During nearshore disposal operations, turbidity would increase temporarily in the water column adjacent to the project. The increased turbidity would be short-term; therefore nearshore placement would have no long-term or significant impacts, if any, on salinity, water chemistry, clarity, color, odor, taste, dissolved gas levels, nutrients or eutrophication

(2) Current Patterns and Circulation : Net movement of water is from the north to the south. The project would have no significant effect on existing current patterns, current flow, velocity, stratification, or the hydrologic regime in the area.

(3) Normal Water Level Fluctuations: Mean tidal range in the project area is 3.5 feet with a spring tide range of approximately 4.1 feet.

(4) Salinity Gradients: Salinity is that of oceanic water. Dredged material placement would not affect normal tide fluctuations or salinity.

(5) Actions That Will Be Taken to Minimize Impacts: BMPs and other benthic protection measures have been coordinated with the resource agencies to minimize impacts.

c. Suspended Particulate/Turbidity Determinations

(1) Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Disposal Site: There may be a temporary increase in turbidity levels in the project area along the disposal site during discharge. Turbidity would be short-term and localized and no significant adverse impacts are expected. State water quality standards for turbidity outside an allowable mixing zone would not be exceeded.

(2) Effects (degree and duration) on Chemical and Physical Properties of the Water Column: The sea floor, at this location, is characterized by a sandy substrate nearshore and sand/silt substrate at the ODMDS. There would be little, if any, adverse effects to chemical and physical properties of the water as a result of placing sandy material in the nearshore and sand/silt/rock material at the ODMDS.

(a) Light Penetration: Some decrease in light penetration may occur in the immediate vicinity of the disposal area. This effect would be temporary, limited to the immediate area of construction, and would have no adverse impact on the environment.

(b) Dissolved Oxygen: Dissolved oxygen levels would not be altered by this project due to the high energy wave environment and associated adequate reaeriation rates.

(b) Toxic Metals and Organics: No toxic metals or organics are expected to be released by the project.

(d) Pathogens: No pathogens are expected to be released by the project.

(e) Aesthetics: The aesthetic quality of the water in the immediate area of the project would be reduced during construction due to increased turbidity. This would be a short-term and localized condition. Material placed in the nearshore would likely provide improved beach width down drift of placement location.

(f) Others as Appropriate: None.

(3) Effects on Biota

(a) Primary Production, Photosynthesis: Primary productivity is not a recognized, significant phenomenon in the surf zone, where a temporarily increased level of suspended particulates would occur. There would be no effect on the nearshore productivity as a result of the proposed disposal area.

(b) Suspension/Filter Feeders: An increase in turbidity could adversely impact burrowing invertebrate filter feeders within and adjacent to the immediate construction area. It is not expected that a short-term, temporary increase in turbidity would have any long-term negative impact on these highly fecund organisms.

(c) Sight Feeders: No significant impacts on these organisms are expected as the majority of sight feeders are highly motile and can move outside the project area.

(4) Actions taken to Minimize Impacts: BMPs and other benthic protection measures have been coordinated with the resource agencies to minimize impacts.

d. Contaminant Determinations: The material that would be disposed would not introduce, relocate, or increase contaminants at the area. The material would consist of sandy material with some silt in the nearshore and material with higher concentrations of rock in the ODMDS.

e. Aquatic Ecosystem and Organism Determinations: The material that would be placed in the nearshore would be similar enough to the existing substrate so that no impacts are expected. The materials meet the exclusion criteria, therefore, no additional chemical-biological interactive testing would be required.

(1) Effects on Plankton: No adverse impacts on autotrophic or heterotrophic organisms are anticipated.

(2) Effects on Benthos: The material would bury some benthic organisms. Benthic organisms found in the intertidal areas along the project disposal area are adapted for existence in an area with considerable substrate movement, thus most would be able to burrow up through the disposed material. Recolonization is expected to occur within a year after construction activities cease. No adverse long-term impacts to non-motile or motile benthic invertebrates are anticipated.

(3) Effects on Nekton: No adverse impacts to nektonic species are anticipated.

(4) Effects on Aquatic Food Web: No adverse long-term impact to any trophic group in the food web is anticipated.

(5) Effects on Special Aquatic Sites: There are no hardground or coral reef communities located in the immediate nearshore area that would be impacted by disposal activities. **Chapter 5** of the integrated FR/EIS offers a more detailed discussion on impacts.

(6) Threatened and Endangered Species: Appropriate measures to avoid, minimize, and mitigate for impacts to listed species have been fully coordinated with NMFS and USFWS.

(7) Other Wildlife: No adverse impacts to small foraging mammals, reptiles, or wading birds, or wildlife in general are expected.

(8) Actions to Minimize Impacts: BMPs along with terms and conditions associated with ESA Biological Opinions would be followed.

f. Proposed Disposal Site Determinations

(1) Mixing Zone Determination: Material placed in the nearshore would meet requirements outlined in the Water Quality Certificate. Placement would not cause unacceptable changes in the mixing zone water quality requirements as specified by the State of Florida's Water Quality Certification permit procedures. No adverse impacts related to depth, current velocity, direction and variability, degree of turbulence, stratification, or ambient concentrations of constituents are expected from implementation of the project.

(2) Determination of Compliance with Applicable Water Quality Standards: Because of the inert nature of the material to be to be disposed, Class III water quality standards would not be violated.

(3) Potential Effects on Human Use Characteristic

(a) Municipal and Private Water Supply: No municipal or private water supplies would be impacted by the implementation of the project.

(b) Recreational and Commercial Fisheries: Fishing in the immediate construction area would be prohibited during construction. Otherwise, recreational and commercial fisheries would not be impacted by the implementation of the project.

(c) Water Related Recreation: Beach/water related recreation in the immediate vicinity of construction would be prohibited during construction activities. This would be a short-term impact.

(d) Aesthetics: The existing environmental setting would not be adversely impacted. Construction activities would cause a temporary increase in noise and air pollution caused by equipment as well as some temporary increase in turbidity. These impacts are not expected to adversely affect the aesthetic resources over the long term and once construction ends, conditions would return to pre-project levels.

(e) Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves: No such designated sites are located within the project area.

g. Determination of Cumulative Effects on the Aquatic Ecosystem: There would be no cumulative impacts that result in a major impairment in water quality of the existing aquatic ecosystem resulting from the placement of material at the project site.

h. Determination of Secondary Effects on the Aquatic Ecosystem: There would be no secondary impacts on the aquatic ecosystem as a result of the dredging.

III. Findings of Compliance or Non-Compliance with the Restrictions on Discharge

a. Adaptation of the Section 404(b)(l) Guidelines to this Evaluation: No significant adaptations of the guidelines were made relative to this evaluation.

b. Evaluation of Availability of Practicable Alternatives to the Proposed Discharge Site Which Would Have Less Adverse Impact on the Aquatic Ecosystem : No practicable alternative exists which meets the study objectives that does not involve discharge of fill into waters of the United States. Further, no less environmentally damaging practical alternatives to the proposed actions exist. To test the suitability upland sand sources the borrow areas proposed by the contractor would be used for this project. In addition, the impacts of using other sources on cultural resources, protected species, and other environmental factors would likely be equal to or greater than the impacts of the proposed action. The no action alternative would allow the present condition of the channel to need dredging at increased frequency compared to the preferred alternative.

c. Compliance with Applicable State Water Quality Standards: After consideration of disposal site dilution and dispersion, the discharge of dredged materials would not cause or contribute to, violations of any applicable State water quality standards for Class III waters.

d. Compliance with Applicable Toxic Effluent Standard or Prohibition Under Section 307 Of the Clean Water Act: The discharge operation would not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

e. Compliance with Endangered Species Act of 1973: The disposal of dredged material would not jeopardize the continued existence of any species listed as threatened or endangered or result in the likelihood of destruction or adverse modification of any critical habitat as specified by the Endangered Species Act of 1973, as amended. Standard conditions for monitoring and relocating turtle nests would be employed.

f. Compliance with Specified Protection Measures for Marine Sanctuaries Designated by the Marine Protection. Research, and Sanctuaries Act of 1972: No marine sanctuaries are located within the project area.

g. Evaluation of Extent of Degradation of the Waters of the United States: The placement of dredged material would not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreational and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. The life stages of aquatic species and other wildlife would not be adversely affected. Significant adverse effects on aquatic ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values would not occur.

h. Appropriate and Practicable Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem: Appropriate steps have been taken to minimize the adverse environmental impact of the proposed action. Turbidity would be monitored so that if levels exceed State water quality standards of 29 NTU's above background, the contractor would be required to cease work until conditions return to normal. In the vicinity of reef and other hard grounds, measures would be taken to minimize sediment deposition on sensitive reef organisms.

i. On the basis of the guidelines, the proposed dredging and disposal sites are specified as complying with the requirements of these guidelines.

Appendix D: Environmental
Attachment 2: CZM

LAKE WORTH INLET
Palm Beach Harbor

COASTAL ZONE MANAGEMENT ACT AND FLORIDA COASTAL MANAGEMENT PROGRAM
FEDERAL CONSISTENCY DETERMINATION

LAKE WORTH INLET FEASIBILITY STUDY

Enforceable Policy. Florida State Statues considered "enforceable policy" under the Coastal Zone Management Act (www.dep.state.fl.us/cmp/federal/24_statutes.htm).
Applicability of the Coastal Zone Management Act. The following summarizes the process and procedures under the Coastal Zone Management Act for Federal Actions and for non-Federal Applicants*.

Item	Non-Federal Applicant (15 CFR 930, subpart D)	Federal Action (15 CFR 930, subpart C)
Enforceable Policies	Reviewed and approved by NOAA (in FL www.dep.state.fl.us/cmp/federal/24_statutes.htm)	Same
Effects Test	Direct, indirect (cumulative, secondary), adverse, or beneficial	Same
Review Time	Six (6) months from state receipt of Consistency Certification (30-days for completeness notice). Can be altered by written agreement between State and applicant	60 days, extendable (or contractible) by mutual agreement
Consistency	Must be fully consistent	To maximum extent practicable**
Procedure Initiation	Applicant provides Consistency Certification to State	Federal agency provides "Consistency Statement" to State
Appealable	Yes, applicant can appeal to Secretary (NOAA)	No (NOAA can "mediate")
Activities	Listed activities with their geographic location (State can request additional listing within 30 days)	Listed or unlisted activities in State program
Activities in Another State	Must have approval for interstate reviews from NOAA	Interstate review approval NOT required
Activities in Federal Waters	Yes, if activity affects State waters	Same

* There are separate requirements for activities on the Outer Continental Shelf (subpart E) and for "assistance to an applicant agency" (subpart F).
** Must be fully consistent except for items prohibited by applicable law (generally does not count lack of funding as prohibited by law, 15 CFR 930.32).

1. Chapter 161, Beach and Shore Protection. The intent of the coastal construction permit program established by this chapter is to regulate construction projects located seaward of the line of mean high water and which might have an effect on natural shoreline processes.

Consistency Statement: The purpose of the proposed action is to improve and maintain safe navigation depths in Palm Beach Harbor/Lake Worth Inlet, Palm Beach County, Florida. Information will be submitted to the State for a permit in compliance with this chapter.

2. Chapters 186 and 187, State and Regional Planning. These chapters establish the State Comprehensive Plan, which sets goals that articulate a strategic vision of the State's future. Its purpose is to define in a broad sense, goals and policies that provide decision-makers directions for the future and long-range guidance for orderly social, economic and physical growth.

Consistency Statement: The project meets the primary goal of the State Comprehensive Plan. The proposed work will be coordinated with the State through review of this document.

3. Chapter 252, Disaster Preparation, Response and Mitigation. This chapter creates a State Emergency Management Agency, with authority to provide for the common defense; to protect the public peace, health and safety; and to preserve and protect the lives and property of the people of Florida.

Consistency Statement: This chapter does not apply.

4. Chapter 253, State Lands. This chapter governs the management of submerged State lands and resources within State lands. This includes archeological and historic resources; water resources; fish and wildlife resources; beaches and dunes; submerged grass beds and other benthic communities; swamps, marshes and other wetlands; mineral resources; unique natural features; spoil islands; and artificial reefs.

Consistency Statement: The proposed activity will be coordinated with the State and appropriate State permits will be obtained. The proposed action will be consistent with the intent of this chapter.

5. Chapters 253, 259, 260 and 375, Land Acquisition. These chapters authorize the State to acquire land to protect environmentally sensitive areas.

Consistency Statement: The proposed action is being coordinated with the State of Florida. The project is consistent with this chapter.

6. Chapter 258, State Parks and Aquatic Preserves. This chapter authorizes the State to manage State parks and preserves. Consistency with this chapter would include consideration of projects that would directly or indirectly adversely impact park property, natural resources, park programs or management or operations.

Consistency Statement: The proposed action will not impact any State parks or preserves. This chapter is not applicable.

7. Chapter 267, Historic Preservation. This chapter establishes the procedures for implementing the Florida Historic Resources Act responsibilities.

Consistency Statement: The proposed action has been coordinated with the State Historic Preservation Officer (SHPO) and is consistent with the intent of this chapter.

8. Chapter 288, Economic Development and Tourism. This chapter directs the State to provide guidance and promotion of beneficial development through the encouragement of economic diversification and promotion of tourism.

Consistency Statement: The proposed improvements and maintenance thereof are consistent with the goals of this chapter.

9. Chapter 334 and 339, Public Transportation. This chapter authorizes the planning and development of a safe and efficient transportation system.

Consistency Statement: The proposed action will not adversely affect public transportation and therefore would be consistent with the goals of this chapter.

10. Chapter 370, Living Saltwater Resources. This chapter directs the State to preserve, manage and protect the marine crustacean, shell and anadromous fishery resources in State waters; to protect and enhance the marine and estuarine environment; to regulate fishermen and vessels of the state engaged in the taking of such resources within or without State waters; to issue licenses for the taking and processing of fisheries products; to secure and maintain statistical records of the catch of each such species; and to conduct scientific, economic and other studies and research.

Consistency Statement: Marine crustacean, shell, and andromous fishery resources will be temporarily impacted. Temporary and permanent impacts will occur within the marine and estuarine environment. These impacts will be mitigated.

11. Chapter 372, Living Land and Freshwater Resources. This chapter establishes the Game and Freshwater Fish Commission and directs it to manage freshwater aquatic life and wild animal life and their habitat to perpetuate a diversity of species with densities and distributions which provide sustained ecological, recreational, educational, aesthetic and economic benefits.

Consistency Statement: The work in Lake Worth Inlet and Palm Beach Harbor will be consistent with the goals of this chapter.

12. Chapter 373, Water Resources. This chapter provides the authority to regulate the withdrawal, diversion, storage and consumption of water.

Consistency Statement: This work does not involve water resources as described in this chapter.

13. Chapter 376, Pollutant Spill Prevention and Control. This chapter regulates the transfer, storage and transportation of pollutants and the cleanup of pollutant discharges.

Consistency Statement: This work does not involve the transportation or discharge of pollutants. Conditions will be placed in the contract to handle inadvertent spills of pollutants such as vehicle fuels. The proposed action will comply with this chapter.

14. Chapter 377, Oil and Gas Exploration and Production. This chapter authorizes the regulation of all phases of exploration, drilling and production of oil, gas and other petroleum resources.

Consistency Statement: The proposed action does not involve the exploration, drilling, or production of oil, gas, or other petroleum products; therefore this chapter does not apply.

15. Chapter 380, Environmental Land and Water Management. This chapter establishes criteria and procedures to assure that local land development decisions consider the regional impact of large-scale development.

Consistency Statement: The proposed action is consistent with the intent of this chapter.

16. Chapter 388, Arthropod Control. This chapter provides for a comprehensive approach for abatement or suppression of mosquitoes and other arthropod pests within the State.

Consistency Statement: The work will not further the propagation of mosquitoes or other pest arthropods. The proposed action will be consistent with the goals of this chapter.

17. Chapter 403, Environmental Control. This chapter authorizes the regulation of pollution of the air and waters of the State by the Department of Environmental Protection.

Consistency Statement: Appropriate State permits will be obtained for this project.

18. Chapter 582, Soil and Water Conservation. This chapter establishes policy for the conservation of State soils and water through the Department of Agriculture. Land use policies will be evaluated in terms of their tendency to cause or contribute to soil erosion or to conserve, develop and utilize soil and water resources both on-site and on adjoining properties affected by the work. Particular attention will be given to work on or near agricultural lands.

Consistency Statement: The proposed action is not located near agricultural lands; therefore, this chapter does not apply.

Appendix D: Environmental
Attachment 3: Mitigation Plan

LAKE WORTH INLET

Palm Beach Harbor

ATTACHMENT 3 – MITIGATION PLAN

This report outlines compensatory mitigation for unavoidable impacts to seagrass and hardbottom habitats impacted by implementation of the Recommended Plan evaluated in the Environmental Impact Statement (EIS). Impacts to the total project include 4.5 acres of seagrass habitat and 4.9 acres of hardbottom habitat outside of or deeper than the present authorized channel width and depth. Of these impacts, mitigation will be required for seagrass and hardbottom habitats where new construction dredging is proposed. The South Atlantic Fishery Management Council (SAFMC) and National Marine Fisheries Service (NMFS) (SAFMC 1998) consider all of these habitat types Essential Fish Habitat (EFH). For dredging the rock/rubble and silt/sand/rubble bottom within the channel, mitigation is not proposed since dredging was previously performed in the channel and temporal impacts are minimal.

The following mitigation plan complies with the requirements of Section 2036 of the Water Resources Development Act of 2007 (WRDA 2007) and "complies with the mitigation standards and policies established pursuant to the regulatory programs".

Mitigation Options

A total of 16 options have been identified that could serve as full or partial mitigation for impacts to seagrasses and hardbottoms within Lake Worth Lagoon (Table 1, Figure 1). The amount of site specific information known at this time varies among projects listed below. Table 1 summarizes the mitigation potential of each site identified to date.

Submerged aquatic seagrass colonies occur within federal channels of the proposed project area where dredging will occur and on the immediately adjacent buffer. The search for available candidate sites was researched by contacting Palm Beach County Department of Environmental Resource Management, which has a proven success record with comparable restoration and mitigation. The site has significant need of restoration; thus, the U.S. Army Corps of Engineers has the opportunity to contribute to the community as well as compensate for impact to seagrass within the Lake Worth Lagoon Watershed.

Based on previous coordination with Federal, state, and local resource agencies, in-kind restoration of seagrass and hardbottom habitat is the agency-preferred option for mitigating for said impacts.

The Habitat Equivalency Assessment (HEA) analysis was used to calculate mitigation amounts, and has been well-coordinated with the resource agencies. Since the exact amount of mitigation will not be known until Planning Engineering and Design (PED), when a final resource survey can be completed and mitigation amounts based on functional value can be calculated, an estimate of mitigation cost was prepared at the feasibility level. This estimate was determined by researching mitigation required in other Jacksonville District Civil Works projects, as well as mitigation required in permits issued by Jacksonville District Regulatory Division for hardbottoms.

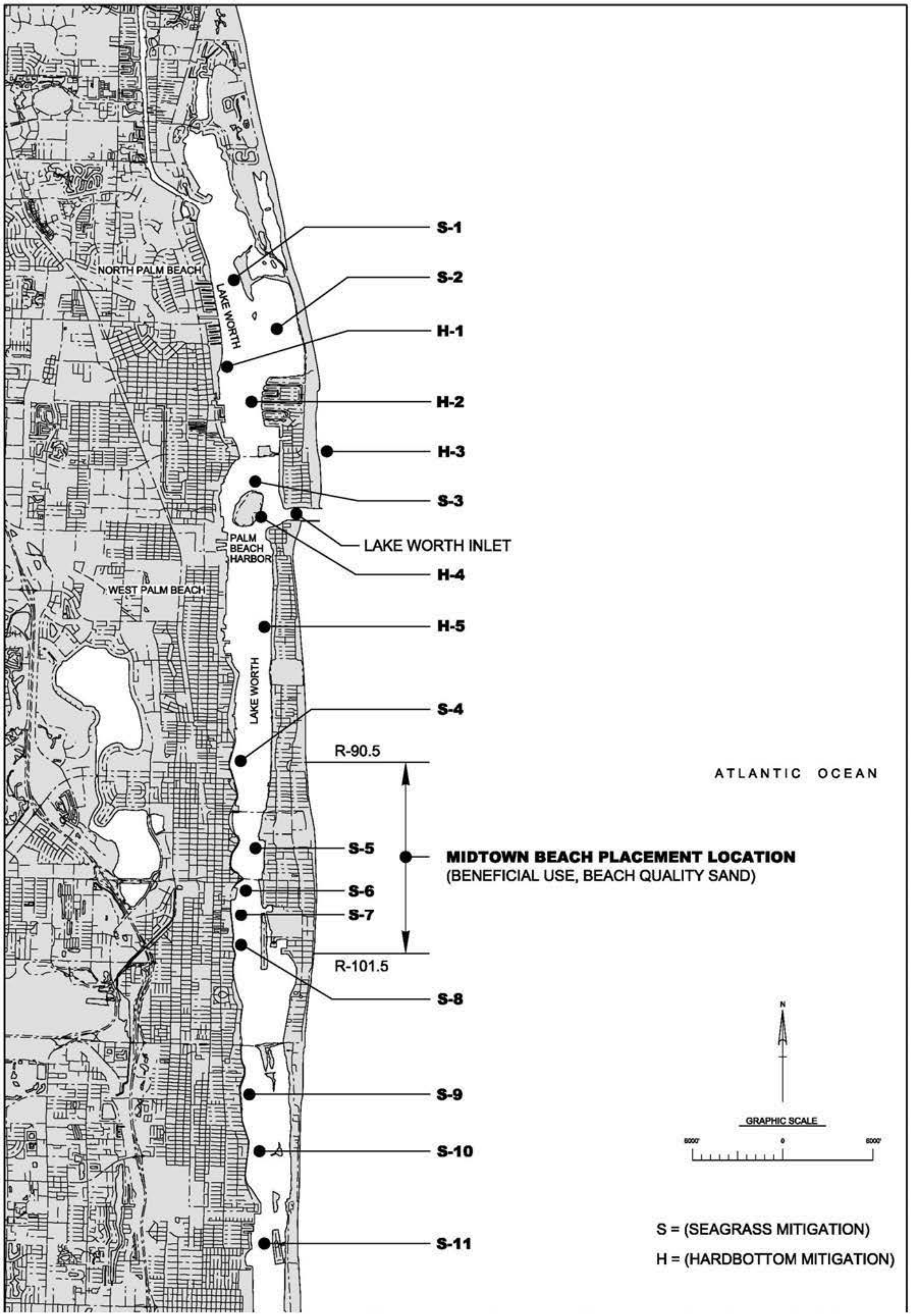


Figure 1. Locations of proposed mitigation sites.

Table 1. Mitigation options and estimated available acres

Project Name	Project Type	Site Conditions	Habitat Created
S-1	Filling/Capping	37.8 ac dredge hole > 750,000cy3 capacity	>10 ac seagrass
S-2	Acquisition Conservation	147 ac of privately held submerged lands w/ healthiest seagrass bed in LWL	Purchase & Preservation by adjoining to J.D. MacArthur Beach State Park
S-3	-Dredging -Artificial Hardbottom	30 ac shoal >100,000 cy3 sand to be dredged	10 ac seagrass (temporary-may accrete) 1 ac art hardbottom
S-4	Filling/Capping	25 ac dredge hole >525,000cy3 capacity	>10 ac seagrass
S-5	Filling/Capping	28ac dredge hole >738,000cy3 capacity	>10 ac seagrass
S-6	Filling/Capping	21 ac dredge hole >380,000cy3 capacity	>10 ac seagrass
S-7	Filling/Capping	2.7 ac dredge hole >60,000cy3 capacity	2.7 ac seagrass
S-8	Filling/Capping	18.7 ac dredge hole >390,000cy3 capacity	>10 ac seagrass

Project Name	Project Type	Site Conditions	Habitat Created
S-9	Filling/Capping	7.5 ac dredge hole >98,000cy3 capacity	7.5 ac seagrass
S-10	Filling/Capping	5.2 ac dredge hole >117,000cy3 capacity	5.2 ac seagrass
S-11	Filling/Capping	68 ac dredge hole >1,980,000cy3 capacity	>10 ac seagrass
H-1	Artificial Hardbottom	6 ac permitted site contains 2 ac art hardbottom 4 ac remain for new hardbottom creation	4 ac art hardbottom
H-2	Artificial Hardbottom	10 ac permitted site contains 7ac art hardbottom 3 ac remain for new hardbottom creation	3 ac art hardbottom
H-3	Artificial Hardbottom	Permitted nearshore site 4ac art hardbottom built & under 5yr monitoring plan. 2 ac remain for new hardbottom creation	2 ac art hardbottom
H-4	Artificial Hardbottom	SE Peanut has existing breakwaters 3 ac remain for new hardbottom creation	3 ac area for additional breakwaters
H-5	Artificial Hardbottom	5 ac permitted site contains 3 ac art hardbottom 2 ac remain for new hardbottom creation	2 ac art hardbottom

3.0 Mitigation Requirements

3.1 Seagrass

Direct impacts to seagrass communities are restricted to the widening of Palm Beach Harbor entrance channel and widening of the existing turning basin to the north and south. Impacts include the permanent loss (removal) of 4.5 acres of mixed seagrass beds. Losses will occur from both the widening footprint and the natural equilibration of the side slopes as described in the EIS. Neither Federal or State agencies have objected to the methods to mitigate proposed impacts described in the draft EIS. The acreages and numbers provided are a conservative planning estimate considering project level details and are aligned with similar Jacksonville projects reviewed and authorized by the regulatory agencies. Mitigation needs from impacts to seagrasses were calculated using the HEA model. The HEA model was used to calculate the impacts to seagrasses and resulted in a mitigation acreage of 11.25, which about 2.5 times the area of impact (4.5 acres). This is also comparable to mitigation requirements in other Jacksonville District civil works projects and regulatory permits.

In order to replace local seagrass functions and values, restoration will be implemented within Lake Worth, preferably in areas where seagrass once occurred and is now absent due to past anthropogenic activities such as dredging. Seagrass habitat will be restored by filling old borrow areas located within Lake Worth to result in a minimum surface area of 11.25 acres of new seagrass beds. Based on a discussions with the Palm Beach County Department of Environmental Resource Management (ERM) in August of 2012, there are several old borrow areas which were considered suitable for filling with dredged material, capping with sand, and restoring seagrass habitat to an elevation consistent with the depths where adjacent seagrass beds are present (Table 1).

Restoration of seagrass communities, while still considered experimental by some resource agencies, can enhance habitat heterogeneity and the diversity of invertebrate and fish communities, if carefully implemented. The recent treatise on seagrass restoration entitled "Guidelines for the Conservation and Restoration of Seagrasses in the United States and Adjacent Waters" by Fonseca et al. (1998) discusses the benefits, risks, and successful approaches associated with seagrass restoration. Given the documented success of more recent efforts to restore seagrass communities including those in South Florida, restoration is quickly becoming a proven resource management tool in some areas where conditions are appropriate.

Table 2. Dredging Impacts by Habitat Type

Habitat Type and Current Dredge Status	Component				
	B-2	**C**	**D**	**G**	**Total**
Seagrass- new impacts with project footprint and side slope equilibration (acres)	0.0	0.4	**2.0**	2.1	**4.5**

3.2 Hardbottom

To calculate the acreage of creation of artificial hardbottom required for compensation, the Corps performed a Visual Habitat Equivalency Analyses (HEA) (see NOAA 2000). The method used was designed to take into account both projected impact acreages for various habitats and recovery times to calculate the overall loss of habitat function that occurs from the time a new impact occurs to the time of full functional recovery. HEA is usually applied to situations where previously non-impacted habitats are damaged and was used, in this case, to calculate compensatory mitigation acreages for removal of habitat in previously undredged areas. Projected impact acreages were classified according to the method that would be applied to calculate functional loss. This was necessary because the proposed mitigation will be type-for-type, to reflect the need to mitigate for similar habitat types and expected species within the impacted area and the mitigation location.

Several assumptions are involved in the HEA method. These assumptions include (1) the relative functionality (usually expressed as a percentage) of both impact and mitigation areas at "time-0" (time zero) (i.e., at the initiation of mitigation operations or at the time the impact occurs to the habitat), (2) the relative functionality of both the impact and mitigation area at the completion of recovery of each area, (3) the form of the recovery function (e.g., linear, exponential, hyperbolic, etc.), and (4) the recovery/completion time for the impact area and mitigation area to reach full functionality (i.e., the level that existed prior to impact/mitigation activities

Based on research of other projects in Jacksonville District, an average multiplier of 2.3 times the acreage of impact (4.9) was used to calculate estimated mitigation acreage needs for hardbottoms during the Feasibility Phase. The estimate of hard bottom mitigation acreage (11.25 acres) is conservative and expected to be reduced during PED upon completion of a final resource survey and functional value calculations.

4.0 Proposed Plan

This mitigation plan focuses on compensation options available for unavoidable impacts associated with implementation of the recommended plan to seagrass and hardbottom habitats located within Lake Worth. Other options evaluated did not provide in-kind type-for-type replacement of habitat lost and may not be acceptable to the resource agencies unless opportunities to provide like replacement were not available or did not have a likely probability of success.

4.1 Seagrass Restoration

In order to replace local seagrass functions and values, restoration will be implemented in an area near Lake Worth within an area that has been anthropogenically disturbed in the past (Fonseca et al. 1998). Several previously identified dredge hole sites located throughout Lake Worth are being considered (see Figure 1/Table 1). The final site will be determined based on several factors including:

- a good candidate for cost-effective hauling or pumping of borrow material from the project site for the purpose of topographic restoration (subject to a cost-feasibility analysis),
- experience a relatively calm but well-circulated tidal current and little or no daily perturbations from boating activities, and,
- there are sites within the hole that can be restored to seagrass over a sufficient area to achieve the desired amount of mitigation.

Based on the combined observations of the latest bathymetry and the subsequent discussions with the Palm Beach County Department of Environmental Resources Management, the following screening criteria were developed to assist in locating a specific seagrass restoration site within the Lake Worth area. The preferred site should:

- maximize the facilitation of natural recruitment from adjacent Johnson's beds,
- avoid impacts to existing seagrass both outside and within the site,

- have sufficient access and working area for the required equipment with no risk of damage to adjacent shallow resources.

The preferred seagrass restoration site should have the following characteristics:

- The site varies in depth from about 12 to 17 feet.
- Portions of the site are bordered by steep walls while other portions are bordered by sloping topography.
- Those portions of the site below the 16 to 17 foot contour are unvegetated.
- Areas of natural grade adjacent to the site are dominated by Johnson's with *H. decipiens* and *H. wrightii* also being present.

4.1.1 Conceptual Seagrass Site Design

The goal of the mitigation is to compensate for the loss of climax-community seagrass habitat at the impact site by restoring a productive climax-community seagrass habitat at the mitigation site. To compensate for 4.5 acres of projected seagrass losses at the impact site, a minimum of 11.25 acres of seagrass habitat are expected to be constructed within the Proposed Seagrass Mitigation Site . However, the Corps has the option to construct more than 11.25 acres of habitat if he sees it economically feasible. The Corps has the option of conducting mitigation prior to construction or simultaneously.

A pre-construction survey will be conducted within a reference site that will serve as a background area for comparison of species composition, density, patchiness, and other characteristics. The reference site should be located within the same general vicinity of the mitigation site and be at a comparable depth to the final target elevation of the mitigated seagrass. Success is defined as achievement of the target acreage of seagrass coverage within 5 years of site construction. Success will be determined by coverage based on the Braun-Blanquet technique (Braun-Blanquet 1965) comparing the mitigated site to reference sites of similar species composition in the surrounding area.

Cover Class	Description
0	Absent or no measurable cover
0.1	Solitary shoot with small cover
0.5	Few shoots, less than 5% cover
1	Numerous shoots, less than 5% cover
2	Any number of shoots but with 5% to 25% cover
3	Any number of shoots but with 25% to 50% cover
4	Any number of shoots but with 50% to 75% cover
5	Any number of shoots but with >75% cover

Success determination will be accomplished by counts of plant shoots and estimation of percent coverage within sample quadrat and sub-quadrat to determine density and percent coverage (in contrast to bare areas). Using the impact areas as a reference and based on recent surveys of the impact area in 2008 and 2011, there is less than or equal to 50% density of seagrass species on average within the impacted areas.

The success criteria for vegetation establishment within restored areas include:

- Braun-Blanquet score within one (1) unit of reference site within 3 years
- Seagrass density equal to or greater than the 50% density recorded at the impacted areas within 5 years
- A mix of seagrass species composition similar to impacted areas within 5 years

Contingency measures as part of the Adaptive Management Plan will be implemented if indicators determine that success criteria are not being met, and that the restoration is determined to be failing.

To achieve mitigation success, the following steps will be implemented:

1. Fill unvegetated areas with native material (dredged material) to the base fill elevation or to the elevation at which seagrass communities will grow to restore topography for climax community seagrasses (target elevation).
2. Utilize dredged material of a consistency that will allow for settling and achievement of stable slopes and for support of the maximum possible surface area of fine capping fill material.
3. Using finer capping fill material, create a stabilized surface treatment of approximately 11.25 acres (assumed acreage) to achieve an elevation and substrate composition suitable for recruitment of seagrasses.
4. Design the site to maximize recruitment from adjacent seagrass beds but also incorporate strategic planting to achieve recovery if it does not occur naturally through recruitment within the desired timeframe.

To achieve these objectives, dredged material would either be barged up/down the ICW or pumped to the mitigation site. The site boundaries will be clearly delineated in the field prior to deposition of fill. The first step will be to fill the holes to the base fill elevation. The base fill elevation is estimated to be between (-) 5 to (-) 7 feet MLLW, or the elevation below which seagrass communities no longer grow. Where the delineated site border meets a steep pit wall, the fill will be leveled as closely as possible to adjacent seagrass elevation (target elevation) in order to encourage recruitment and also to improve connectivity of the restoration site to the adjacent seagrass bed community. In these specific areas, some resources may be covered by material on the narrow eroded shelf described earlier that occurs between natural grade and the sharp drop. Wherever the delineated site border does not meet a steep wall the fill will be sloped up from the base fill elevation in order to avoid impacting existing seagrasses. The material will be deposited in two phases: coarse fill phase and capping phase. The coarse fill phase will attempt to utilize dredge material for the purpose of providing a supporting base for the site. Any mixture of rock and/or sandy material is acceptable for this phase provided that stable compaction and slopes are achieved. The coarse fill will be brought to within a minimum two feet of the final target elevation for the site, approximately (-) 6 to (-) 8 feet MLLW. The capping phase will utilize finer grain material suitable for seagrass recruitment and will be brought up to the target elevation, approximately (-) 4 to (-) 6 feet MLLW. The capping material will be constructed to an elevation between (-) 4 to (-) 6 feet MLLW maximum, with a minimum two-foot depth. The contractor will be provided with criteria that will limit the quality of the material to be placed in the mitigation site. At this time, there are no specific criteria provided by resource agencies, therefore USACE will develop standards to be followed. At a minimum, material will have less than 20% fines, and will be required to match as closely as possible to characteristics of surrounding material; however, turbidity standards will be the ultimate controlling parameter. Further details limiting composition will be provided in the project plans and specifications. Although the site design does not specifically seek to provide seagrass or other communities on the side slopes of the mounded areas, it is likely that either seagrass and/or hardbottom communities (calcareous algae and sponges) will grow on the side slopes, based on observations in the field of similar features as the mitigation site.

As a potential option to further increase the growth rate of seagrass, the use of bird roosting stakes may be explored. Bird stakes provide an inexpensive option to help promote seagrass growth by increasing nutrient loading through nitrogen and phosphorus enriched feces. Bird roosting stakes should be constructed using ½ - ¾ inch diameter PVC pipe capped with a pressure treated wooden block, ranging in size from 2 in. by 2 in. by 4in, or alternatively 4 in. by 4 in. by 2 in (Kenworthy et al. 2000 and FP&L 2010). Roosting stakes should be placed in a uniform grid across the mitigation area with no greater than ½ acre by ½ acre cells. Stakes should remain in place for up to two years, pending achievement of success criteria (FLP, 2010). The Corps would coordinate with FDEP/FWC before use of bird stakes to ensure proper use and management. Coordination with the U.S. Coast Guard will be required to ensure bird stakes are clearly marked as navigational hazards with the use of "No Boating" signs in the mitigation area.

It is currently envisioned that the construction of the site would incorporate the following features:

- Transport: Barge access would be restricted to deep water. Additional channel surveys will need to be conducted prior to transport to verify depths. Barges may need to be light-loaded in the event the channel depths are not sufficient to accommodate full loads. If a piping method is used, the pipe could be placed in deep water wherever possible. The transport method is not expected to have significant impacts on surrounding seagrass beds adjacent to the transport route or the mitigation site.
- Turbidity Control: Some method of turbidity control such as curtains would be employed at the site in order to ensure compliance with state water quality standards. Significant turbidity is not expected during construction since the majority of the fill will consist of coarse grain material that will drop quickly during deployment. The calm conditions that make this site a good seagrass restoration candidate will also help to contain turbidity.
- Site Grading: Regardless of the method used to transport and deploy the fill, site finishing and grading will need to achieve the target elevation as closely as possible. A flat-blade excavator will most likely be used to grade the site to the specified elevation, but a combination of methods may be used.
- Planting: Planting will not initially be conducted with the assumption that natural recruitment will be successful. Monitoring will be conducted up to 5 years to ensure growth progress and success. In the event seagrass does not recruit as anticipated after 3 years, planting will be considered. Individual plots of *H. wrightii* and/or Johnson's may be distributed over portions of the site in areas where recruitment may otherwise be slow to occur based on post construction monitoring reports.

Once constructed, the site will be monitored. Monitoring will be designed to evaluate achievement of the following:

- Recruitment of the site with seagrasses within 3 years, and
- Achievement of the target acreage of seagrass coverage within 5 years.

It is anticipated that seagrass recruitment will occur rapidly by Johnson's and *H. decipiens*. Other species including *H. wrightii* are expected to colonize the site at a slower rate.

In order to ensure the mitigation design is properly achieved, surveys will be taken after each stage of construction. Once the coarse fill material is placed, a survey will be taken to verify the target elevation of (-) 6 to (-) 8 feet MLLW is achieved. Any fill material will be removed or added in the event the target elevation is not successfully met. An additional survey will be conducted once the capping material has been placed to ensure accuracy. Sedimentation monitoring will be conducted in the adjacent seagrass beds to ensure material from the construction mitigation site is not shifting to existing areas, and will also ensure capping material is not significantly shifting once the site is completed. Sedimentation traps will be placed throughout the surrounding area and data will be collected regularly based on the schedule provided in a detailed monitoring plan which will be completed once the actual site is chosen. Upon completion, the seagrass mitigation site will be monitored on a monthly basis for the first year, then twice a year for years two and three, and once a year for years four and five. Specific details of physical and sedimentation monitoring will be further outlined in the detailed monitoring plan once the site is chosen.

4.2 Artificial Hardbottom Creation

The proposed mitigation for hardbottom impacts will be type-for-type to ensure proper species recruitment is achieved. A total of 4.9 acres of low relief-low complexity (LRLC) hardbottom will be impacted by the widening and depending footprint and associated side sloe equilibrium. To compensate for these impacts, a total of 11.25 acres of mitigation is proposed. The proposed location for mitigation of hardbottom, Singer Island Artificial Reef is found in Figure 1 and Figure 4. The Corps has the option of conducting mitigation prior to construction or simultaneously. Specific design requirements and the hardbottom design are described in this section.

Figure 4. Proposed hardbottom mitigation site

4.2.1 General Design Requirements

Artificial hardbottoms are often proposed for mitigating impacts to natural hardbottom habitats as a result of construction project (Lutz 1998). Artificial hardbottoms have been used successfully for many years to mitigate impacts in sheltered waters (Duffy 1985; Davis 1985) or in relatively deep water offshore (Mostkoff 1993). Palm Beach County has had considerable success with deploying shallow water artificial hardbottoms as mitigation measures. The proposed design reflects the limitations on design and placement imposed by navigation regulations, liability issues, construction limitations, and stability concerns.

The most desirable areas for creation of hardbottom are areas that have a thin veneer of sand over bedrock, which limits the extent that deployed materials will settle. After reviewing the Palm Beach county permitted sites, it was determined that one of the sites (Singer Island Artificial Reef) already has some artificial hardbottom located within the boundaries, which would allow for quicker colonization of artificial hardbottom material, as well as allowing for easier monitoring since it is adjacent to a county mitigation site that is currently monitored. Water depths of this site are similar to the depths of low relief hardbottoms being impacted by the proposed project (8-12 feet). Several other permitted sites referenced in this plan were reviewed for potential use and are still possibilities for use depending on permitting, final mitigation needs and site availability.

4.2.2 Hardbottom Design

Clean limestone rock excavated from the Entrance Channel or quarried native limestone will be used in hardbottom construction. The material will be deployed to mimic the orientation of typical natural hardbottoms. This hardbottom design will have a vertical relief of 3 to 4 feet and rocks will be deployed to provide the maximum structural complexity and to provide refugia for cryptic and reclusive species. As interstitial sand patches associated with hardbottom habitat are thought to be important in the ecological function of the hardbottom habitat, the hardbottom footprint will be 20 by 40 feet with space between modules consisting of mainly sand. Temporary buoys delineating the deployment strip will mark areas for deployment. Corner buoys for the sites shall be placed using Differential Global Positioning System (DGPS) with sub-meter accuracy. Natural limestone provides an ideal substrate for the establishment of a fouling community and colonization by the common hardbottom community species. Rock will be placed by crane and barge to ensure proper placement within the site.

Construction of mitigation hardbottoms may take place during dredging of the project, such that suitable rock material excavated from the channel may be used for hardbottom building.

4.2.3 Hardbottom Monitoring

The monitoring program for the mitigation hardbottoms will consist of both physical and biological components. An initial pre-construction monitoring event will be performed to provide baseline conditions for future comparison. Physical monitoring will assess the degree of settling of the hardbottom materials after the first year, and biological monitoring will assess populations of algae, invertebrates, and fishes, as compared with concurrent control sampling of natural hardbottoms for five years. Monitoring will be conducted annually in the summer months. In order to provide a permanent record of hardbottom conditions and biota, each sampling effort will include video transects covering representative areas of the mitigation hardbottoms.

Fish population evaluations will be based on visual censuses conducted via point-count method (Bohnsack and Bannerot 1986) used for fish assessment. This method has the advantage of gathering quantitative data in a relatively short time in a very repeatable pattern that is relatively insensitive to differences in habitat structure. Each census will have durations of 5 minutes and a radius (the distance from the stationary observer) of 10 feet. Ten censuses will be collected on the mitigation site. Data from these types of censuses are rarely distributed, so the Wilcoxon Rank-Sum or a similar nonparametric test will be used for significance testing.

Results of all mitigation hardbottom-monitoring efforts will be summarized in an annual report to be completed by December 31 of each year the monitoring program is in place. Copies of the report will be distributed to all agencies and interested parties.

Success of mitigation site will be determined by comparison to natural communities of similar biologic assemblages within the project area. Transects (quadrats) will be compared at reference sites and mitigation site for species composition, percent cover and benthic assemblages. At each sampling location, a 0.7 m2 (1.0 × 0.7 m) PVC quadrat will be placed on the substrate. For each quadrat in situ mapping was conducted of all species including the dominant groups of Porifera and Hydroids, macroalgae, and other sessile invertebrates to lowest possible taxonomic rank. In addition to the in situ mapping of each quadrat, photographs will be taken to serve as a permanent visual record of the quadrats and qualitatively document the benthic community development on the artificial reef material. Bray-Curtis similarity indices (Bray and Curtis, 1957), which incorporate both species richness and species density into the calculations, will be used for analysis. Success is determined as a 75% similarity to the natural reference sites in terms of benthic assemblages and Bray-Curtis analysis within 5 years.

5.00 Adaptive Management Plan

In the event that restoration measures fail to meet the goals as established by the success criteria as documented by monitoring event data, Adaptive management measures will be enacted and include:

- Plant seagrass species by shoot transplanting or re-seeding.
- Placement of bird stakes to encourage seagrass recruitment
- Utilize additional injury sites that show more promise of successful establishment than those currently in use
- Additional monitoring events or prolonged schedule until success criteria is documented as accomplished
- Create additional hardbottom habitat at a different location

6.00 Entity Responsible for Monitoring

All monitoring associated with this mitigation plan will be completed by or under the direction of the U.S. Army Corps of Engineers; if the monitoring event is completed by a third party, this activity will be conducted under the direction and on behalf of the U.S. Army Corps of Engineers. Therefore, the U.S. Army Corps of Engineers will retain total responsibility of all activities related to the monitoring of this mitigation. The financial responsibility for post-construction monitoring will be cost shared according to the cost sharing tables shown in the main report.

REFERENCES

Dunankl, M.J., M.O. Hall,and M. Merello, 2002. *Patterns of Change in the Seagrass dominated Florida Bay Hydroscope*; in *The Everglades, Florida Bay and Coral Hardbottoms of rhe Florida Keys, An Ecosystem Sourcebook*. Porter, J.W. and Porter, K.G., Eds., CRC Press, New Your, NY

Fonseca, M.S., W.J. Kenworthy, and G.W. Thayer. 1998. *Guidelines for the Conservation and Restoration of Seagrass in the United States and Adjacent Waters.* NOAA/COP Decision Analuysis Series no. 12, Silver Springs, MD: NOAA Coastal Ocean Office.

Fourqurean, J.W., M.J. Duranko, M.O. Hall, and L.N. Hefty, 2002. *Seagrass Distribution in the South Florida: a Multi-Agency Coordinated Monitoring Program,* in *The Everglades, Florida Bay and Coral Hardbottoms of the Florida Keys*, *An Ecosystem Sourcebook.* Porter, J.W., and Porter, K.G., Eds., CRC Press, Boca Raton, FL.

Kenworthy, W.J., M.S. Fonseca, P.W. Whitfield, K.K. Hammerstrom, and Schwartzschild, 2000. *A Comparison of Two Methods for Enhancing the Recovery of Seagrass into Propeller Scare: Mechanical Imjection of a Nutrient and Growth Hormone Solution vs. Defecation by Roosting Seabirds.* Final Report. Center for Coastal Fisheries and Habitat Research, NCCOS, NOAA, NOS, Beaufort, SC and the Dept. of Environmental Sciences, University of Virginia, Charlottesville, VA.

US Army Corps of Engineers, 2002 *Secion 204 Wcosystem Restoration Preort and Final Environmental Assessment Cockroach Bay, Hillsborough County, FL* Jacksonville District South Atlantic Division

RS Environmental Consulting, Inc for FPL, 2010. Revised Mitigation FPL Plan South Channel Relocation Project Seagrass Restoration in Biscayne Bay Aquatic Preserve (FDEP Permit no 13-0205980-002), Miami, FL

Seagrass Recovery, Inc, website 2011, http://www.seagrassrecovery.com/index.htm
St Petersburg, FL

Appendix D: Environmental
Attachment 4: CEICA for Mitigation

LAKE WORTH INLET
Palm Beach Harbor

Attachment 4

COST EFFECTIVE INCREMENTAL COST ANAYLSIS (CEICA)

FOR MITIGATION

1 COST EFFECTIVE INCREMENTAL COST ANALYSIS (CEICA) METHODOLGY OVERVIEW

The purpose of this CEICA document is to show that multiple mitigation sites were considered to assess cost effectiveness, per guidance required in USACE ER 1102-2-100. The Mitigation Plan in Attachment 3 of the Environmental Appendix D, can and should be referenced for the specific details of the mitigation methodology itself.

Three important ideas should be highlighted for the methodology of assessing cost effectiveness in this document.

First, the exact amount of mitigation will not be known until Planning Engineering and Design (PED), when a final resource survey can be completed and mitigation amounts based on functional value can be calculated, an estimate of mitigation cost was prepared at the feasibility level. This estimate was determined by researching mitigation required in other Jacksonville District Civil Works projects, as well as mitigation required in permits issued by Jacksonville District Regulatory Division for hardbottoms.

Based on research of other projects in Jacksonville District, an average multiplier of 2.3 times the acreage of impact (4.9) was used to calculate estimated mitigation acreage needs for hardbottoms during the Feasibility Phase. The estimate of hardbottom mitigation acreage (11.25 acres) is conservative and expected to be reduced during PED upon completion of a final resource survey and functional value calculations.

The HEA model was used to calculate the impacts to seagrasseses and resulted in a mitigation acreage of 11.25, which about 2.5 times the area of impact (4.5 acres). This is also comparable to mitigation requirements in other SAJ civil works projects and regulatory permits.

In addition, state and Federal agencies have supported these multipliers in past Jacksonville projects and the multipliers discussed above represent a reasonable conservative estimate for mitigation.

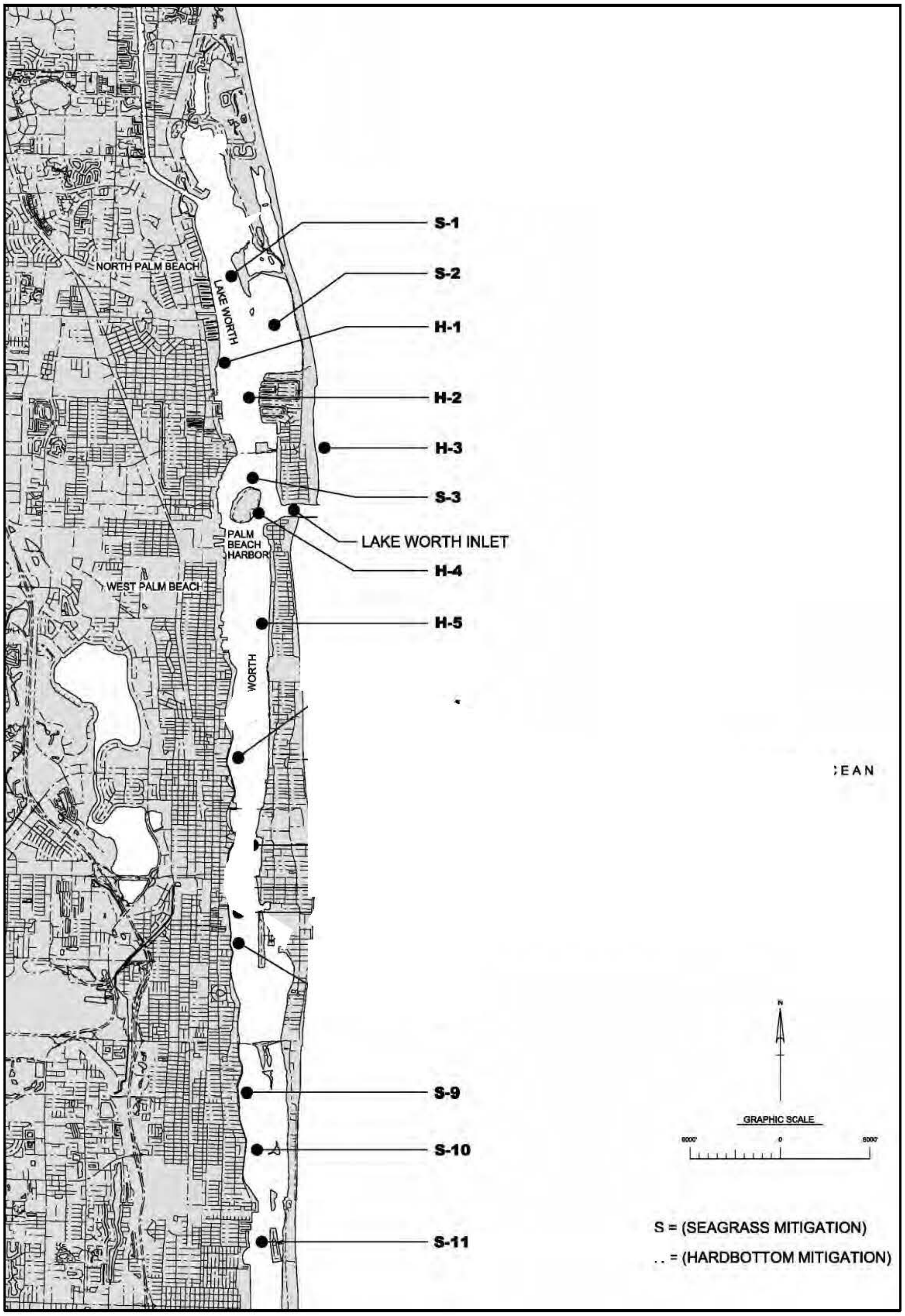
The Florida Department of Environmental Protection (FDEP) requires the use of UMAM for the determination of required mitigation and the UMAM analysis will be included with the submission of the Water Quality Certificate Application. These models are available upon request. The number of acres to mitigate for is a set number, determined by the HEA model and refined through negotiations with the agencies. Therefore, each site will produce the required outputs. When outputs are the same, the basis of comparison for cost-effectiveness is cost per acre.

Second, project impacts are due to widening, not deepening. Therefore, since all the alternatives used the same widening footprint, this CEICA was only done for the NED/TSP/recommended plan.

Third, this document shows the “menu” of currently known and available sites in the Lake Worth Lagoon area and discusses the costs and brief rationale considered. The outcome of this CEICA is only for cost estimating purposes for the feasibility study and is not intended to imply that a final site selection has been made. All sites will be re-assessed during the pre-construction, engineering, and design (PED) phase and will require verification of resources and conditions at that time.

The locations of potential seagrass and hardbottom mitigation sites assessed at this time, are presented below in Figure 1. UPDATE: Since this CEICA was written, 5 new potential sites have been added to the list for seagrass mitigation. These 5 sites are not shown on the map in this appendix, but can be seen in Figure 4-2 (Chapter 4) in the main report. The new sites became known to USACE late in the planning process, and for this reason are not assessed in the CEICA. However, due to similar distances and conditions, cost estimates for the new sites are expected to be on the same order of scale as the sites presented in this analysis, and a risk based contingency is in the cost estimate in case a slightly higher cost or slightly lower cost site is ultimately selected. If one of the new sites is considered for use during PED, its cost will be considered within the CEICA analysis.

Figure 1: Location of potential Seagrass and Hardbottom Mitigation Sites



2 SEAGRASS MITIGATION

2.1 METHODOLOGY OF ESTABLISHING SEAGRASS

Throughout the Lake Worth Lagoon, there are several previously dredged holes which are suitable candidates for seagrass restoration. Their suitability is based on correspondence with Palm Beach County, Environmental Resources Management (ERM), and due to evidence that seagrasses currently grow just outside the holes at the natural, shallower, elevations. Palm Beach County, ERM, has had success regarding filling dredged holes (with no planting) to promote seagrass restoration within the Lake Worth lagoon.

This project would fill dredged holes with dredged suitable, and then would cap the top two feet with suitable select material. The combination of bringing the dredged hole(s) back up to their original elevation of surrounding landscape, and capping with select material, would allow optimum conditions for the existing seagrasses on the outer portions of the hole to grow.

2.2 SEAGRASS MITIGATION BENEFITS

When this analysis was conducted, the impact to seagrasses was estimated at 4.5 acres. This was an approximation used prior to the mitigation ranges shown in the main report. For this analysis, mitigation required was assumed using a 2.5 ratio, with the result that up to 11.25 acres or functional units, could be required.

SEAGRASS ALTERNATIVES

During this analysis, two sites north of the inlet (known as Turtle Cove and Little Lake Worth) were ruled out for use in this feasibility study due to public opposition during the public review period. The locations of the five remaining known potential seagrass mitigation sites are shown in Table 1. Sites S-2 and S-3 were ruled out for cost estimating purposes at this time. S-2 is an area of shoaled sand, and would need to be dredged for seagrass restoration. There is a higher risk that the area would not support seagrasses and furthermore, that the area would beginning accumulating material again. This area had a higher risk of not performing the function of supporting seagrass mitigation, and therefore was not considered further. S-3 was also ruled out because it would involve acquisition of privately owned land, which would be cost prohibitive.

The information, including distance from the project, cost per acre, and available capacity for the 3 potential sites under consideration for seagrasses is listed in Table 1.

Table 1: Seagrass Mitigation Alternatives

Site	Distance (mi)	cost/acre	acres available
S-9	7.03	166,667	9
S-10	7.65	240,000	11.25
S-11	8.83	306,667	11.25

2.3 SEAGRASS SITE

All alternative sites have adequate capacity, with the exception of Alt 4, Bingham Hole. Therefore, this was combined with the next most cost effective alternative, and plans were developed.

Table 2 shows that when the plans are compared, Plan 1 has the least average cost per acre, and therefore the least total cost. However it does not make sense to go to two separate sites, when the next least cost site, Plan 2, can accommodate all the mitigation.

Therefore, Plan 2 (S-10) is the next most cost effective site and can currently accommodate all potentially required mitigation. As a result, this site has been referenced in the cost estimate as a feasible and cost effective site that could be used for the project. This site, as well as other sites, will be re-assessed again during pre-construction, engineering and design (PED) for availability, suitability and compatibility.

Table 2: Seagrass Mitigation Plans

Plan	Site	Distance (mi)	cost/acre	Avg Cost/acre	Acres used	Subtotal cost	TOTAL cost
1	S-9	7.03	166,667		9	$1,500,003	$2,040,003
	S-10	7.65	240,000	181,334	2.25	$540,000	
2	S-10	7.65	240,000	240,000	11.25		$2,700,000
3	S-11	8.83	306,667	306,667	11.25		$3,450,004

3 HARDBOTTOM MITIGATION

When this analysis was conducted, the impact to hardbottom was estimated at 4.9 acres, as a result of the combined effect of loss of habitat in Area C and loss of service in Area B2 due to the widening footprint. This was an approximation used prior to the mitigation ranges shown in the main report. For this analysis, mitigation required was assumed using a 2.3 ratio, with the result that up to 11.25 acres or functional units, could be required.

3.1 METHODOLOGY OF ESTABLISHING HARDBOTTOMS

MATERIAL

Two main options exist for the reef mitigation construction material:

1. Bring in an another source of material to serve as an artificial reef (quarry limestone rock or pre-fabricated material)
2. Use project rock to serve as the artificial reef

Material Option 1 would bring in an outside source of substrate for artificial reef creation. This could be any hard substrate, but most likely would be quarry limestone rock, which has had proven successful for other mitigation projects in the area.

Material Option 2 preserves the live hard bottom habitat as much as possible and would keep project rock within the lagoon system. With this option, at this stage in the feasibility study, there is uncertainty of what size of rock will be obtained with the dredge.

Material Option 1, using quarry limestone rock will be pursued as it is the most reliable means of establishing mitigation at this time. Using other sources of substrate may be revisited if the opportunity arises and Option 2 may be revisited during the project pre-construction, engineering and design phase (PED) when geotechnical properties of the project rock are better understood.

PLACEMENT METHODS

Two broad options exist for mitigation placement methods, listed below, assuming that quarry limestone is being brought in from outside the project:

1. Crane-barge and scow barge
2. Diver placement

Placement Method 1 would be used if a source of rock was brought in, such as limestone boulders. An excavator and clamshell would still be used for the dredging portion, but would also require additional equipment consisting of a crane at the dockside loading location for picking up the mitigation material, loading the mitigation material on barges or split-hull scows, and using a crane-barge at the mitigation site to place the mitigation material from the barge.

For Placement Method 2, the excavator and clamshell would still be used for the dredging portion. Divers would be used to place each piece of hard bottom, rather than the split hull barges. This method would be extremely costly and potentially unsafe.

It is most likely, for performance and cost, that placement method 1 would be an acceptable method. Therefore, the crane-barge and scow barge will be assumed.

3.2 HARDBOTTOM ALTERNATIVES

The locations of the potential hardbottom mitigation sites are shown in S-2 and S-3 were ruled out for cost estimating purposes at this time. S-2 is an area of shoaled sand, and would need to be dredged for seagrass restoration. There is a higher risk that the area would not support seagrasses and furthermore, that the area would soon beginning accumulating material. This area had a higher risk of not performing the function of supporting seagrass mitigation, and therefore was not considered further. S-3 was also ruled out because it would involve acquisition of privately owned land, which would be cost prohibitive. The information, including distance from the project, cost per acre, and available capacity for five sites under consideration is listed in Table 3.

Table 3: Hardbottom Mitigation Alternatives

Site	Distance (mi)	cost/acre	acres available
H-1	2.5	612,500	4
H-2	1.8	683,333	3
H-3	2.4	995,556	11.25
H-4	0.6	1,250,000	1
H-5	1.2	725,000	2

3.3 HARDBOTTOM SITE

Out of the five sites, only one (H-3) has enough capacity for the currently assumed mitigation of 11.25 acres. Therefore, this was combined with the next most cost effective alternative, and plans were developed.

Table 4 shows that when the plans are compared, Plan 1 has the least average cost per acre, and therefore the least total cost. However, this plan is not logistically favorable as it includes placing material at 4 different sites. Plan 4 is the next most cost-effective, but again is not logistically favorable as it still includes placement at 3 different sites. Plan 3 allows all the needed mitigation to occur at one site, and has the highest chance of success due to the proven pod formations which currently exist, as well as for availability at the time of project construction.

Table 4: Hardbottom Mitigation Plans

Plan	Site	Distance (mi)	cost/acre	Avg Cost/acre	acres used	Subtotal cost	TOTAL cost
1	H-1	2.5	612,500		4	$2,450,000	$8,190,000
	H-2	1.8	683,333		3	$2,049,999	
	H-5	1.2	725,000		2	$1,450,000	
	H-3	2.4	995,556	728,000	2.25	$2,240,001	
2	H-3	2.4	995,556		10.25	$10,204,449	
	H-4	0.6	1,250,000	1,018,173	1	$1,250,000	$11,454,449
3	H-3	2.4	995,556	995,556	11.25	$11,200,005	$11,200,005
4	H-2	1.8	683,333		3	$2,049,999	
	H-3	2.4	995,556		7.25	$7,217,781	
	H-4	0.6	1,250,000	934,914	1	$1,250,000	$10,517,780

Therefore, Plan 3 (H-3) is the mitigation site which was used in the cost estimate as a feasible and cost effective site that could be used for the project. This site, as well as other sites, will be re-assessed again during pre-construction, engineering and design (PED) for availability, suitability and compatibility.

4 CONCLUSION

In conclusion, a "menu" of potential candidate sites has been researched for seagrass and hardbottom mitigation sites. The current cost estimate references S-10 as a cost effective site which could be used for seagrass mitigation, and the cost estimate references H-3 as a cost effective site which could be used for hardbottom mitigation. Both cost estimates were refined in the total project cost estimate presented in the main report and cost appendix, and thus vary slightly from the estimates presented in this analysis. Sites and considerations will be further re-evaluated for availability, suitability and compatibility during pre-construction, engineering, and design phase (PED).

Appendix D: Environmental
Attachment 5: Surveys

LAKE WORTH INLET
Palm Beach Harbor

Seagrass Survey,
Federal Navigation Channel and Harbor Area,
Lake Worth Inlet, Palm Beach Harbor, FL

Final Report

January 2012

Prepared for:
U.S. Army Corps of Engineers
Jacksonville District
701 San Marco Blvd.
Jacksonville, FL 32207

Prepared by:
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Jacksonville Beach, FL 32250

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1.0 INTRODUCTION

Dial Cordy and Associates Inc. (DC&A) was contracted under contract No. GS-10F-0124L (Jacksonville District Work Order W912EP.11-F-0016) by the U.S. Army Corps of Engineers (USACE) to determine the pre-construction condition of the benthic environment with respect to seagrasses and hardbottom resources surrounding the existing federal navigation channel and harbor area in Lake Worth Inlet, Palm Beach County, FL (Figure 1).

The Lake Worth Inlet, within Palm Beach County is within the *Halophila johnsonii* critical habitat. *H. johnsonii* was listed as a threatened species by National Marine Fisheries Service (NMFS) on September 14, 1998 (63 FR 49035) and a re-proposal to designate critical habitat pursuant to Section 4 of the Endangered Species Act (ESA) was published on December 2, 1998 (64 FR 64231). The final rule for critical habitat designation for *H. johnsonii* was published April 5, 2000 (Federal Register, vol. 65, No. 66). *H. johnsonii* has one of the most limited geographic ranges of all seagrass species. It is only known to occur between Sebastian Inlet and northern Biscayne Bay on the east coast of Florida (Kenworthy 1997). This report and others (PBS&J 2009) document the occurrence of *H. johnsonii* within the project area (Figure 1).

2.0 TECHNICAL APPROACH

This section describes the technical approach used to collect and analyze data associated with the benthic surveys conducted in August of 2011 in Lake Worth Inlet, Palm Beach County, FL.

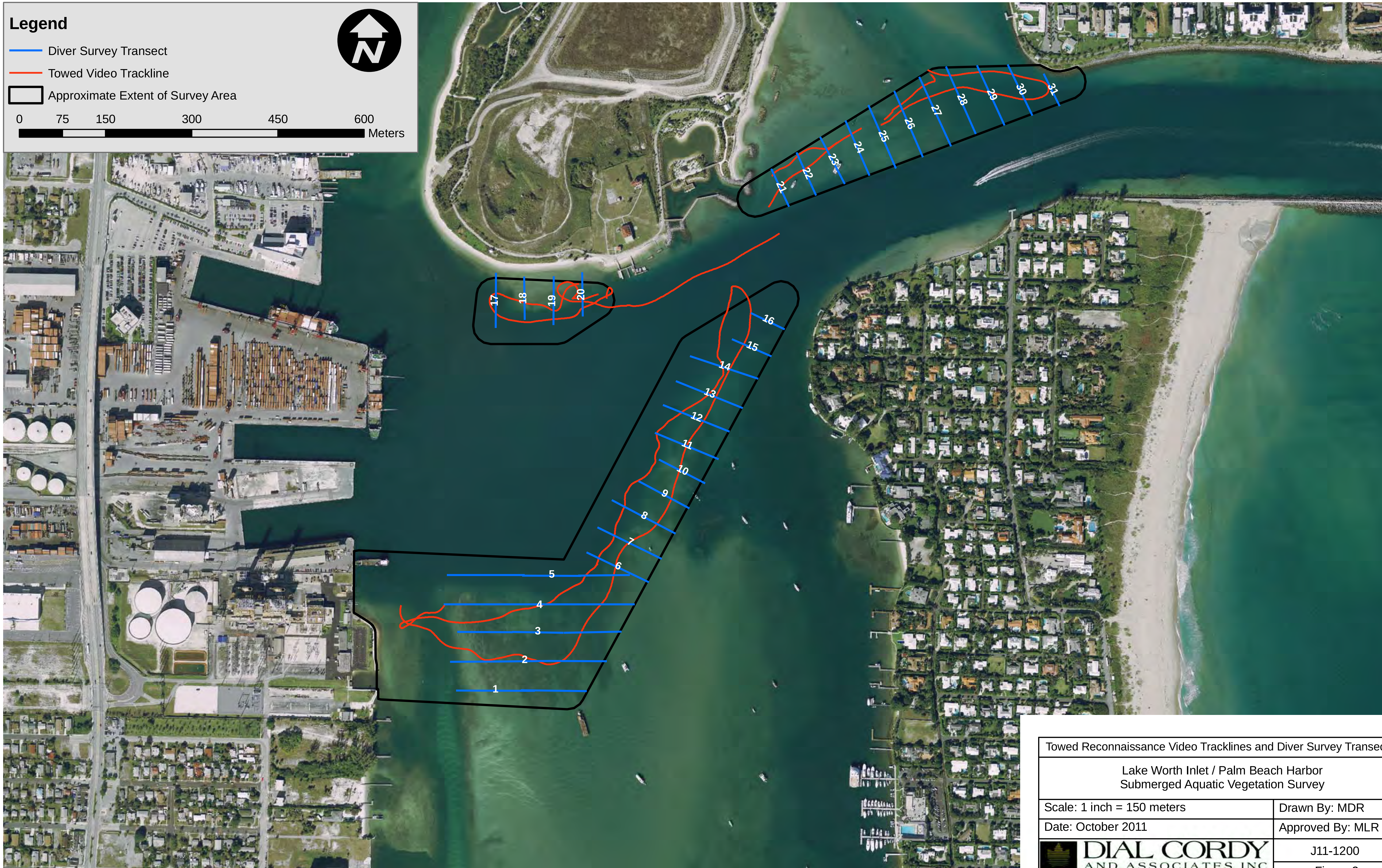
2.1 Marine Resource Survey

A description of methods utilized to document and characterize marine benthic resources within the study area (Figure 1) is provided below. The survey was conducted from August 17-30, 2011.

2.1.1 Reconnaissance Survey

A towed video reconnaissance survey was performed utilizing an integrated towed calibrated video system which records high definition digital video and is linked to geo-referenced navigational software and a precision positioning system (DGPS) with sub-meter accuracy. Such geo-referenced navigational software programs display the geographical coordinates in real time. The calibrated video system included a single camera facing forward and downward at a ~315° angle and traveled at a speed of 1-2 knots behind the vessel. The video was viewed in real time aboard the survey vessel's video screen and recorded directly to mini-DVs, and later transferred to CD. Continuous video transects were towed sinuously across the project site (Figure 2) (Appendix A).

Survey Area Location Map	
Lake Worth Inlet / Palm Beach Harbor Submerged Aquatic Vegetation Survey	
Scale: 1 inch = 250 meters	Drawn By: MDR
Date: October 2011	Approved By: MLR
DIAL CORDY AND ASSOCIATES INC Environmental Consultants	J11-1200
	Figure 1



Towed Reconnaissance Video Tracklines and Diver Survey Transects	
Lake Worth Inlet / Palm Beach Harbor Submerged Aquatic Vegetation Survey	
Scale: 1 inch = 150 meters	Drawn By: MDR
Date: October 2011	Approved By: MLR
DIAL CORDY AND ASSOCIATES INC Environmental Consultants	J11-1200
	Figure 2

2.1.2 Scientific Diver Survey

Scientific diver surveys were conducted in areas where seagrasses were identified as present during the towed video reconnaissance survey and followed the "Recommendation for Sampling *Halophilia johnsonii* at a project site" (Fonseca et al. 1998). Since seagrasses were pervasive except in the northeastern portion of the project area, survey transects were placed in all project site polygons. Per the NOAA recommended survey protocol for "large sites," 28 survey transects were placed within polygons C, D, F, and G, perpendicular to the axis of the channel, every 50 meters (150 feet) (Fonseca et al. 1998). Transect lengths included the project area and a 15m (50 foot) buffer on the landward side and where feasible on the channelward side (Figure 2). Divers swam between transects noting the extent of seagrass beds between transects.

Line-intercept and point quadrat data were collected to quantitatively and qualitatively describe the substrate types, assess percent cover, frequency of occurrence, abundance and density of seagrass and species composition within the survey area.

Transects were generally surveyed beginning at the channel edge and proceeded in a landward direction. Transect beginning and end points were recorded using DGPS with sub-meter accuracy in Hypack navigational software. Along each transect, quantitative data were recorded within $1m^2$ square quadrats (centered on the transect line), every 5m, starting at meter mark zero. Each quadrat was subdivided into 100 10 x 10cm sub-units. Data collected within each $1m^2$ quadrat included the number of 10 x 10cm sub-units that contained at least one seagrass shoot, marine benthic invertebrate or macroalgae) (Virnstein 1995; Fonseca et al. 1998; Braun-Blanquet 1965). The Braun-Blanquet abundance scale was also used to estimate the abundance and density of seagrass species (Table 1).

Table 1. Braun-Blanquet Abundance Scale Values

0	Species absent from quadrat
0.1	Species represented by a solitary short shoot, <5% cover
0.5	Species represented by a few (< 5%) short shoots, <5% cover
1.0	Species represented by many (> 5%) short shoots, <5% cover
2.0	Species represented by many (> 5%) short shoots 5% - 25% cover
3.0	Species represented by many (> 5%) short shoots 25%- 50% cover
4.0	Species represented by many (> 5%) short shoots 50%- 75% cover
5.0	Species represented by many (> 5%) short shoots 75%-100% cover

2.1.3 Seagrass Quantitative Data

Quantitative seagrass data were processed to provide transect frequency of occurrence, abundance, and density for each seagrass species as follows:

Frequency of occurrence = Number of occupied sub-units/total number of sub-units
Abundance = Sum of abundance scale values/number of occupied quadrats
Density = Sum of abundance scale values/total number of quadrats

2.1.4 Hardbottom Quantitative Data

Quantitative data collected for hardbottom habitat included percent cover of each group encountered within the sampled $1m^2$ quadrats, which were placed every 5m along a transect. Data collected for hardbottom benthic invertebrates and algae were collected at the lowest possible taxonomic level and are presented as functional groups in the results. All hard corals encountered, whether or not they fell within the surveyed $1m^2$ quadrat, were recorded by species and size.

2.1.5 Transect Qualitative Data

Qualitative line-point intercept data were collected within a 2m swath along the centerline of each transect. Scientific divers surveyed each transect noting the linear extent of bottom type within a 2m wide area swath, centered on the transect line. Habitat classifications were developed from the qualitative data collected and used for habitat mapping (Table 2).

Table 2. Habitat Classification System Used for Mapping of Habitat Types

Habitat Types	Description
Halophila decipiens	Monospecific bed of this species
Halophila decipiens/Halophila johnsonii	Mixed beds of these species
Halophila johnsonii	Monospecific bed of this species
Halophila johnsonii/Halodule wrightii	Mixed beds of these species
Sand	Sand with no seagrass or live bottom
Sand with cyanobacteria	Sand with cyanobacteria cover
Shell hash	Sand and shell mixture
Sand with scattered hardbottom	Mix of hardbottom and sand
Hardbottom	Continuous hardbottom
Hardbottom ledge	Vertical hardbottom ledge

2.2. Analysis and Interpretation of Marine Habitat Data

Distribution of habitat types and their potential occurrence in an area were mapped for each transect from survey data.

3.0 RESULTS

This section includes a description and review of the results of the benthic community survey, including acreages of marine resources surveyed, percent cover, species occurrence, abundance, and density for seagrasses and hardbottom communities.

3.1. Reconnaissance Survey Results

The towed video reconnaissance survey revealed widespread seagrass and hardbottom communities. Video was qualitatively analyzed aboard the vessel to determine the extent of habitat encountered throughout the survey area. Start and stop GPS points were recorded along the towed trackline to mark habitat types for verification during diver surveys.

3.2. Marine Resource Habitat Types

Seagrass, hardbottom, and sand habitats were identified and assessed within the Lake Worth survey area in August 2011. Of the nearly 50 acres surveyed, 14.6 acres were comprised of seagrasses including the species *Halophila johnsonii*, *H. decipiens* and *Halodule wrightii*. Over ten acres included hardbottom habitat, which included continuous hardbottom, sand with scattered hardbottom, and hardbottom ledge habitats. Nearly half of the survey area consisted of sand, sand covered by cyanobacteria, or shell hash (Table 3 and Figure 3). Photographs were taken to characterize the habitat qualitatively and the complete set of photographs is included as Appendix B.

Table 3. Acreage of marine resources community types including seagrasses, hardbottom, and abiotic bottom by zone.

Community Type	Zone C	Zone D	Zone F	Zone G	Total
Halophila decipiens	0	0.7	1.0	0.5	2.2
Halophila decipiens/Halophila johnsonii	0	0	0.3	3.6	3.9
Halophila johnsonii	1.1	0.6	0.1	4.9	6.7
Halophila johnsonii/Halodule wrightii	0	0.8	0	1.0	1.8
Halodule wrightii	0	0	0.0	0.2	0.2
Sand	2.7	0.8	8.0	3.2	14.7
Sand with cyanobacteria	0	0.4	3.4	2.4	6.2
Shell hash	1.1	0	0	2.4	3.5
Sand with scattered hardbottom	5.4	0.4	0	0	5.8
Hardbottom	3.6	0.3	0.7	0	4.6
Hardbottom ledge	0.1	0	0	0	0.1
TOTAL	**14.0**	**4.0**	**13.5**	**18.1**	**49.6**

Delineation of Submerged Aquatic Vegetation and Marine Habitat	
Lake Worth Inlet / Palm Beach Harbor Submerged Aquatic Vegetation Survey	
Scale: 1 inch = 150 meters	Drawn By: MDR
Date: October 2011	Approved By: MLR
DIAL CORDY AND ASSOCIATES INC Environmental Consultants	J11-1200
	Figure 3

3.3 Seagrass Communities

Seagrass habitat cover type, abundance, and density for the study area are described below. Distribution and occurrence observations for the 2011 survey included surveys areas C, D, F, and G (Figure 3). In general, seagrasses occurred throughout the entire project area, with the exception of the northeastern portion of the project area, where hardbottom predominated (Figure 3).

3.3.1 Seagrass Species Frequency of Occurrence, Abundance, and Density

General Occurrence

Marine seagrass species observed within the study area included *Halodule wrightii, Halophila decipiens*, and *Halophila johnsonii*. Of the 28 transects surveyed, marine seagrass species were observed at 19 transects, or 68% of transects. One or more species of seagrass occurred within every zone, C, D, F and G. *H. johnsonii* was present within all zones to some extent. A summary of occurrence records for each transect where seagrass was found is presented in Table 4. Seagrass habitat maps are included in Figure 3.

Frequency of Occurrence

H. johnsonii

H. johnsonii occurred within 16 of the 28 transects sampled. Frequency of occurrence values ranged from 0 to 0.12 with a mean of 0.07. *H. johnsonii* was often growing under filamentous red algae and cyanobacteria (Figure 4a, b).

Other species

H. decipiens occurred within 14 transects sampled, while *H. wrightii* occurred within only seven transects. Frequency of occurrence for *H. decipiens* values ranged between 0 to 0.12 with a mean of 0.03. In comparison, *H. wrightii* had a range of occurrence values between 0 and 0.20 with a mean of 0.07 over the study area.

Abundance

H. johnsonii

Abundance values for *H. johnsonii* ranged from 0.1 to 1.38 among transects. The average abundance for *H. johnsonii* was 0.6 (< 5% cover). *H. johnsonii* had the lowest abundance values of all species over all transects.

Other Species

Cover abundance for *H. wrightii* was low and ranged from 0.5 to 1.2 with a mean 0.66. *H. decipiens* had the highest abundance score for all seagrasses, ranging from 0.5 to 2.33 with a mean of 1.03.

Table 4. Summary of seagrass frequency of occurrence, abundance, and density for each transect where seagrasses were documented.

		Halodule wrightii	Holophila decipiens	Halophila johnsonii	Halodule wrightii	Holophila decipiens	Halophila johnsonii	Halodule wrightii	Holophila decipiens	Halophila johnsonii
Zone	**Transect**	**Frequency of Occurrence**			**Abundance**			**Density**		
G	T01	0.04	0.03	0.12	0.67	2.33	0.56	0.08	0.14	0.34
G	T02	0.02	0.02	0.06	0.50	1.75	0.55	0.05	0.06	0.19
G	T03		0.12	0.08		1.59	0.68		0.29	0.19
G	T04	0.01	0.02	0.05	0.50	1.17	0.50	0.01	0.10	0.14
G	T05		0.00	0.00		0.30	0.50		0.01	0.01
F	T06		0.00	0.01		0.50	0.50		0.02	0.02
F	T08		0.01	0.00		0.75	0.10		0.06	0.00
F	T10	0.00	0.01		0.50	0.50		0.02	0.06	
F	T11		0.07	0.01		1.30	0.50		0.30	0.05
F	T12		0.07			1.25			0.20	
F	T13		0.07			1.33			0.32	
D	T17	0.04	0.03	0.01	1.0	0.33	0.50	0.05	0.05	0.05
D	T18	0.20		0.36	0.71		1.06	0.33		0.57
D	T19	0.18	0.01	0.07	1.21	0.50	0.50	0.47	0.06	0.28
D	T20	0.03	0.03	0.01	0.50	0.50	0.37	0.09	0.16	0.07
C	T21			0.01			0.50			0.03
C	T22			0.07			0.75			0.18
C	T23			0.27			1.38			0.72
C	T24			0.02			0.70			0.14

* Species present but quantity was below 0.01

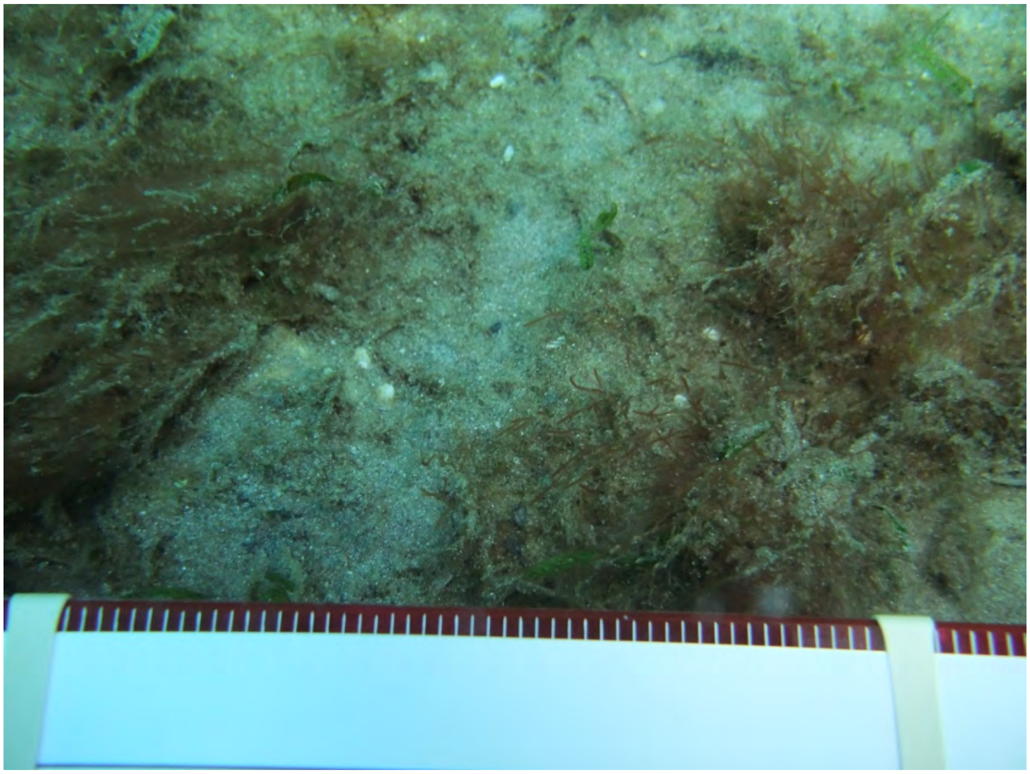


Figure 4 a ***Halophila johnsonii*** **covered in filamentous red algae and cyanobacteria.**

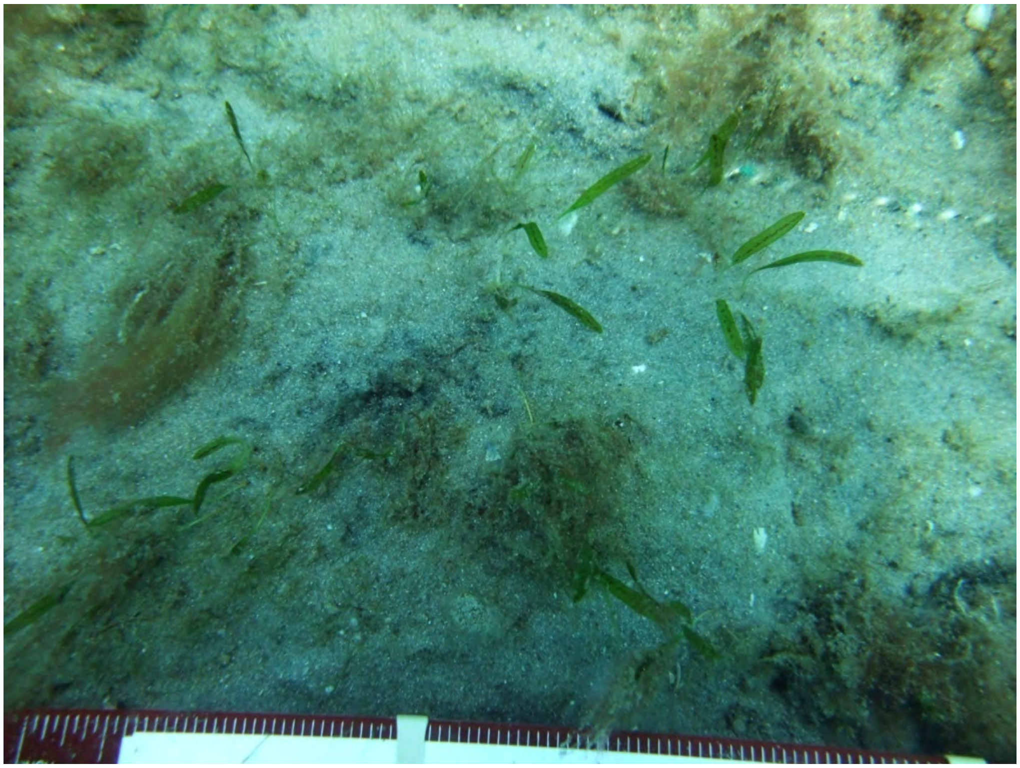


Figure 4 b ***Halophila johnsonii*** **(Braun Blanquet score 1 (<5% cover).**

Density

H. johnsonii

Density for *H. johnsonii* was the highest of all species in the study area, with an average value of 0.17. The range of density values for *H. johnsonii* was 0 to 0.57.

Other Species

H. wrightii had the second highest density values encountered, with a range of 0.01 to 0.47 with an average of 0.15. *Halophila decipiens* had the lowest density of the three species with values ranging from 0.01 to 0.3 with a mean of 0.13.

3.4 Hardbottom Communities

Hardbottom communities occurred in the northeastern portion of the project area within Zones C, D and F, along portions of Transects 15, 16, 17, 20, 25, 26, 27, and 28. Hardbottom communities included areas of continuous hardbottom, sand with scattered hardbottom, and hardbottom ledges (cut edge of channel). Continuous hardbottom areas were places where limestone hardbottom was at the surface or under a thin veneer (>1cm) of sand (Figure 5). The sand with scattered hardbottom habitat type included areas where sand pockets were interspersed with pockets of hardbottom (Figure 6). All hardbottom habitat types supported mixed juvenile and adult reef fish. Some transects had a mix of seagrass and hardbottom habitat types (e.g. T21).

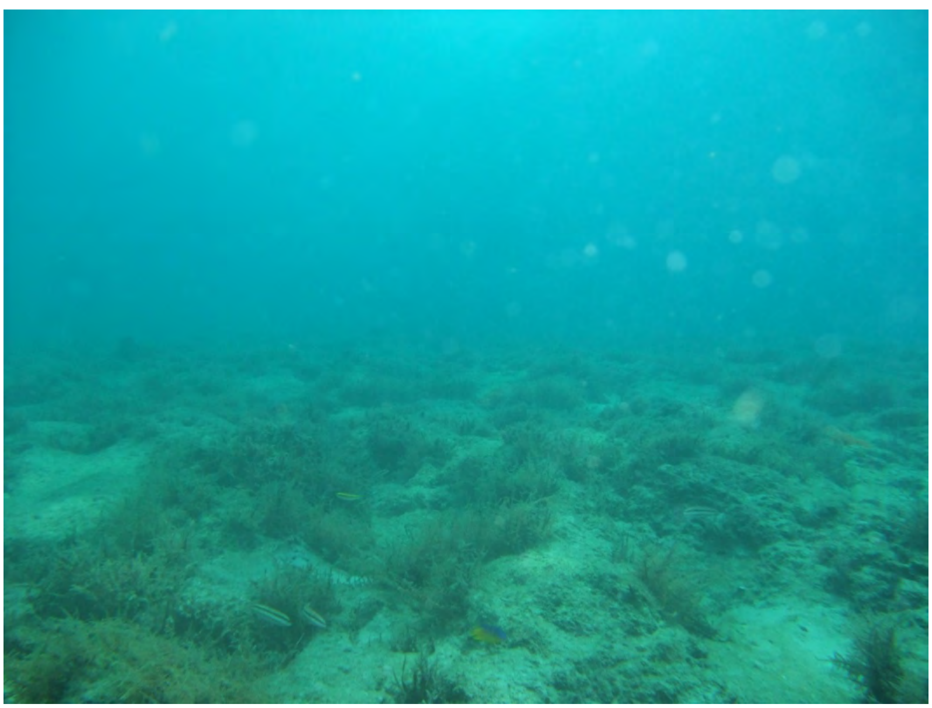


Figure 5 Continuous Hardbottom Habitat with Juvenile Reef Fish in the Foreground.

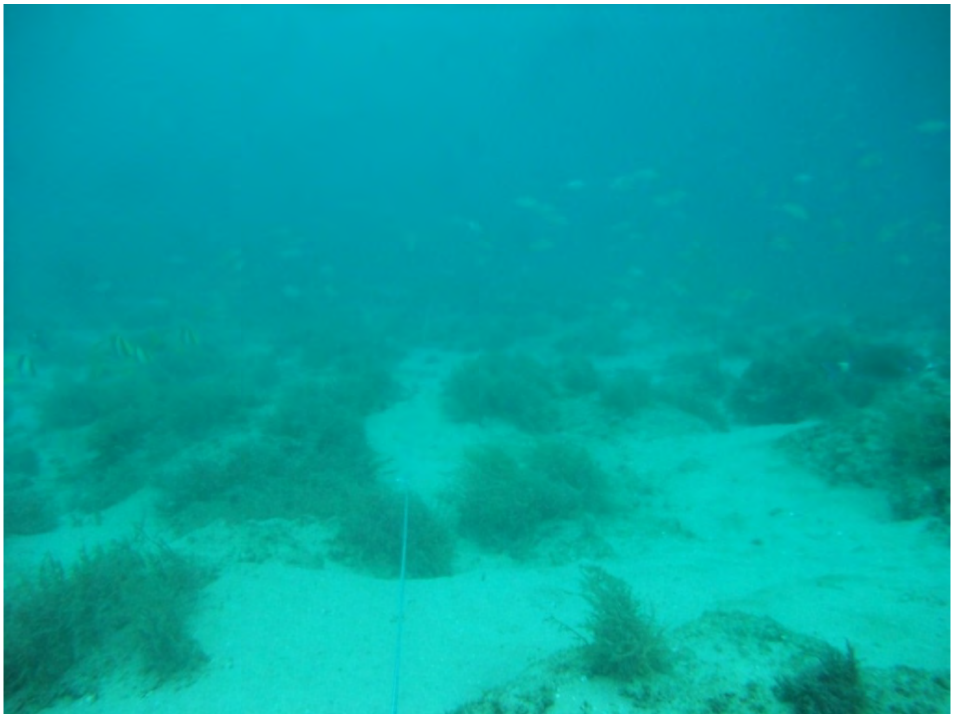


Figure 6   Sand with scattered hardbottom habitat with reef fish.

Continuous hardbottom, sand with scattered hardbottom and hardbottom ledge habitat included a number of benthic organisms unique to hardbottom habitat which were not found in seagrass habitats. Hardbottom benthic organisms were documented to the lowest taxonomic level and are listed in Table 5. Fish populations associated with hardbottom habitat were also documented (Table 6).

Table 5. List of benthic invertebrates and macroalgae documented along transects.

Common Name	Species Name
Sponge	
Black ball sponge	*Ircinia strobilina*
Orange boring sponge	*Cliona delitrix*
Lumpy overgrowing sponge	*Holopsamma helwegi*
Hard Corals	
Lesser starlet coral	*Siderastrea siderea*
Greater starlet coral	*Siderastrea radians*
Hydroids	
Feather bush hydroids	*Dentitheca dendritica*
Macroalgae	
Geen feather algae	*Caulerpa sertularoides*
Y branched algae	*Dictyota* sp.
Oval Blade algae*	*Caulerpa prolifera*

*Documented in seagrass habitat and hardbottom habitat.

Table 6. Fish species documented within project area.

Fish Common Name	Fish Species
Porkfish	*Anisotremus virgincus*
Gray Angelfish	*Pomacanthus arcuatus*
Stoplight Parrotfish	*Sparisoma viride*
Tomtates	*Haemulon aurolineatum*
Grunts (j)	*Haemulon* (spp.)
Blue tang	*Acanthurus coeruleus*
Bluehead wrasse (j,a)	*Thalassoma bifasciatum*

The relative abundance of hardbottom benthic organisms to each other and the percent cover of functional groups along transects is described in Table 7. Hardbottom habitat occurred in Zones C, D, and F, but was not documented in G. Zone C had the greatest cover of hardbottom habitat, followed by Zones F and D. Hard corals were noted along transects, whether or not they fell within 1m^2 quadrats. A total of five hard corals were documented along all transects surveyed and included *Siderastrea siderea* and *S. radians* (Table 8; Figure 7). Noteably, no soft corals were documented during this survey.

Table 7. Percent cover of hardbottom constituents including hydroids, sponge, hard coral, macroalgae, tunicates and bare space along each transect where hardbottom was documented. Transect totals add to 100% only if the entire transect consisted of hardbottom.

Zone	Transect	Hydroid	Sponge	Hard Coral	Macroalgae	Tunicate	Bare	Total
F	**T14**	0	2.3	0	0.5	0.01	2.3	5.11
F	**T15**	3.3	3.3	0	0	0	6.6	13.2
F	**T16**	4.6	2	0	1.2	0.23	12.8	20.83
D	**T17**	0.8	0.8	0	0	0	1.6	3.2
D	**T20**	9.4	3.8	0	0	0.38	24.0	37.58
C	**T21**	0	6.6	0	0	0	10	16.6
C	**T22**	1.6	2	0	0	0	4.4	8
C	**T25**	17.0	1.4	0.05	0	0.05	34.1	52.6
C	**T26**	16.8	0.66	0.06	1.33	0	33.4	52.25
C	**T27**	15.7	3.9	0.04	0	0	71.5	91.14
C	**T28**	18.7	0.83	0	0	0	76.3	95.83

Table 8. Number and size of corals encountered along transects.

Zone	Transect	Species	Size (cm)
D	T20	*Siderastrea radians*	2
C	T25	*Siderastrea radians*	5
C	T25	*Siderastrea radians*	2
C	T26	*Siderastrea radians*	2
C	T26	*Siderastrea siderea*	3

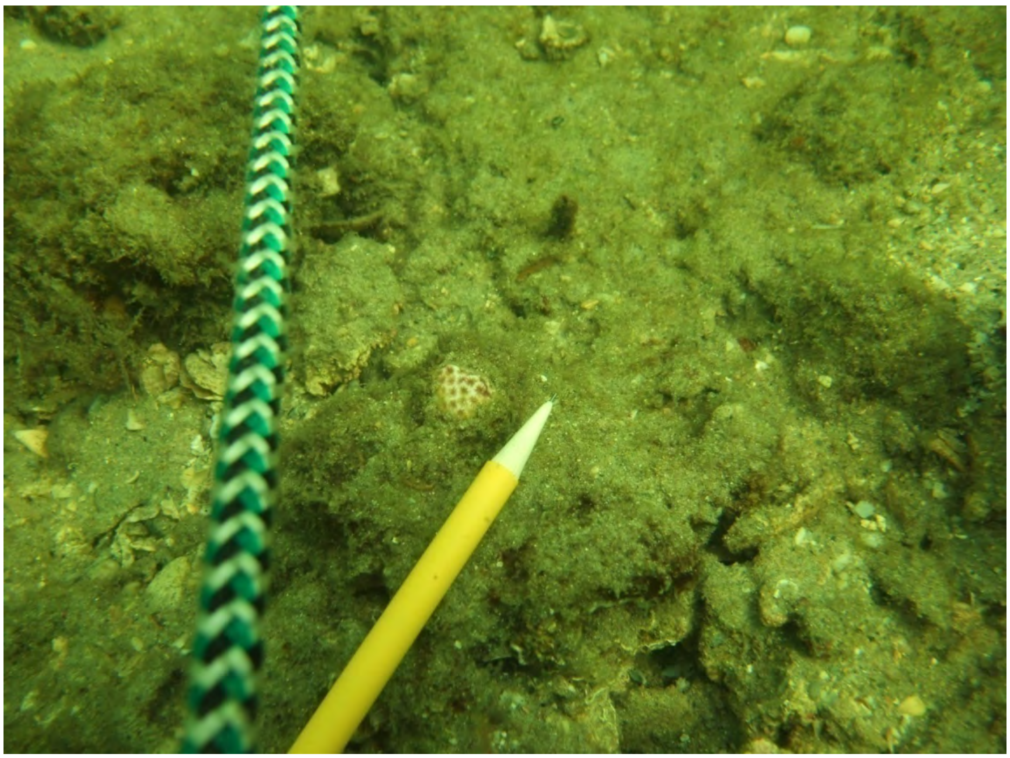


Figure 7 Small *Sidereastrea radians* colony found along Transect 25.

Hardbottom habitat was mostly bare, covered with a thin veneer of sand (<1cm) (Table 7). The dominant hardbottom benthic organisms were feather bush hydroids and sponges. Macroalgae cover was low and patchy in distribution. Solitary tunicates and hard corals were also present.

4.0 DISCUSSION

The benthic survey conducted within the Lake Worth Inlet, Palm Beach Harbor, Palm Beach Florida for the USACE documented seagrass and hardbottom communities within the project area. The surveyed site, nearly 50 acres, included Zones C, D, F, and G (Figure 1). Almost 20 acres, or 40% of the project area surveyed consisted of sand, sand with cyanobacteria, and shell hash habitat type, which were devoid of macro-epibenthic communities. Seagrass beds comprised of *Halophila johnsonii*, *H. decipiens* and *Halodule wrightii* covered 14.6 acres of the project area, while over ten acres included hardbottom habitat types. Seagrass communities were found throughout the project area (Zones C, D, F and G), except within the extreme northeastern portion of the project area (Zone C), where only hardbottom habitat was documented. Hardbottom habitat increased toward the inlet, to the northeast and was not documented in the southern portion of the project area (Zone G) (Figure 3).

Seagrass communities were dominated by sparse cover of *H. johnsonii* in single species and mixed beds in shallow to mid-water depth (0-4m), while *H. decipiens* predominated in water depth greater than 4m. *Halodule wrightii* was also found in shallow water, primarily less than 2m. Frequency of occurrence, cover abundance scores, and density were relatively low for all seagrass beds documented. Frequency of occurrence across an entire transect was highest for *H. johnsonii* along Transect 18, with a value of 0.36 out of a possible 1.0. Cover abundance scores for all species, *H. johsonii*, *H. decipiens* and *Halodule wrightii* were less than 26% cover (maximum of 2.33; Table 4) across all transects; which means that seagrasses covered less than 26% of the bottom where they were found. The highest density score, which is the sum of cover abundance scores for a species, divided by the total number of quadrats within a transect, was 0.72. Overall, seagrass were present in 14.6 acres, but their coverage was low throughout that 14.6 acres.

Hardbottom habitat types including continuous hardbottom, sand with scattered hardbottom, and hardbottom ledge were present within the northeastern portion of the project area and covered nearly 10 acres of the survey area. Bare space, which was limestone rock covered by a thin veneer of sand with no benthic organisms attached to it, was the dominant feature of the hardbottom habitat documented. Hydroids and sponges were the predominant benthic organisms encountered in hardbottom habitat. Hard corals were present, but octocorals were absent. Abundant juvenile and adult reef fish populations utilized all hardbottom habitat types.

5.0 REFERENCES

Braun-Blanquet, J. 1965. Plant sociology: the study of plant communities. Hafner Publications, London. 439p.

Fonseca, M.S., J.W. Kenworthy, and G.W. Thayer. 1998. Guidelines for the Conservation and Restoration of Seagrasses in the United States and Adjacent Waters. NOAA Coastal Ocean Program Decision Analysis Series, No. 12. NOAA Coastal Ocean Office, Silver Spring, MD.

Kenworthy, W.J. 1997. An updated status review and summary of the proceedings of a workshop to review the biological status of the seagrass *Halophila johnsonii* Eisemon. Report to Office of Protected Species, NMFS, NOAA. 23pp.

Kenworthy, W.J. 1993. The distribution, abundance and ecology of Halophila johnsonii Eiseman in the lower Indian River, Florida. Final Report to the Office of Protected Resources, National Marine Fisheries Service, Silver Spring, MD. 72pp.

PBS&J and Ardaman and Associates. 2008. Palm Beach Harbor Navigation: Feasibility Study Environmental Resources Report: A complete submerged aquatic resources survey for the Port of Palm Beach, extending from the 42-ft contour shoreward. Conducted June-October 2008. Prepared for the Corps of Engineers. 81pp.

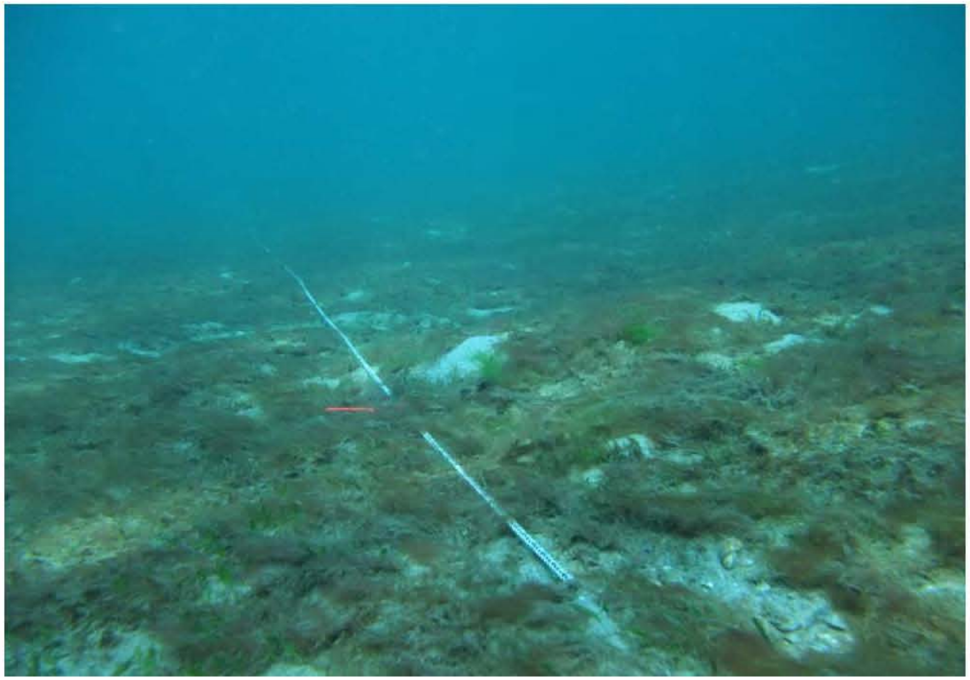
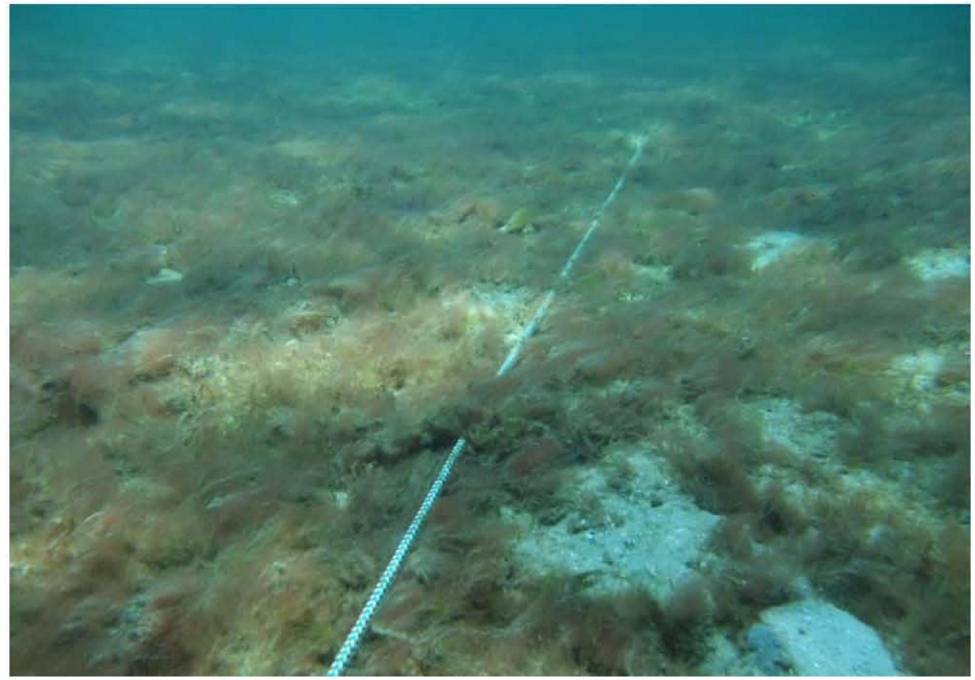
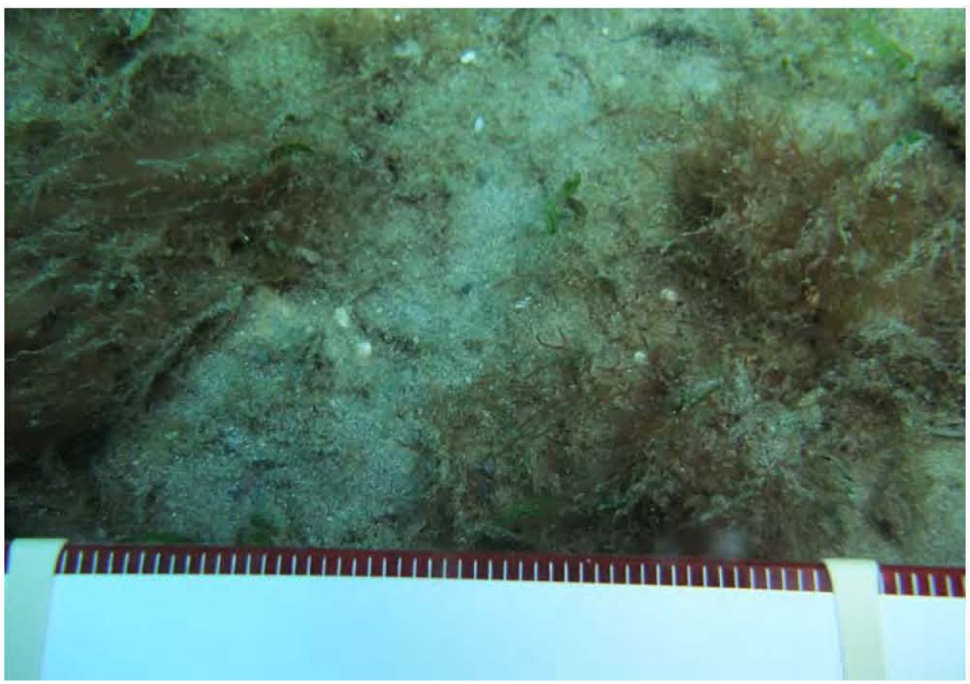
Virnstein, R.W. 1995. Seagrass landscape diversity in the Indian River Lagoon, Florida: The Importance of scale and pattern. Bulletin of Marine Sciences. 57(1):67-74.

APPENDIX A

Reconnaissance Towed Video Survey (DVD)

APPENDIX B

Habitat Photographs

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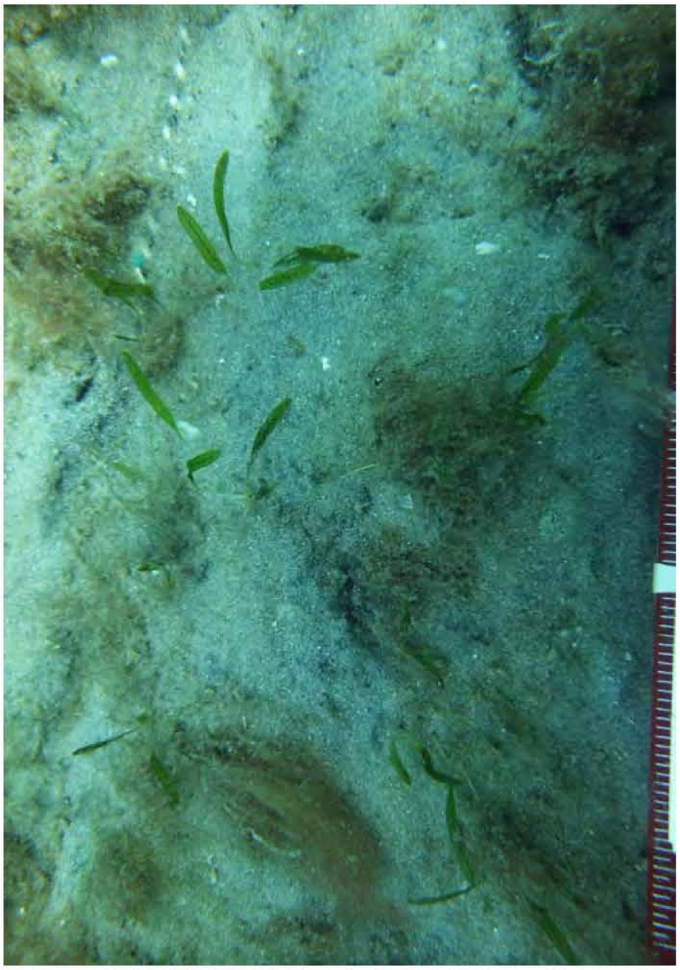
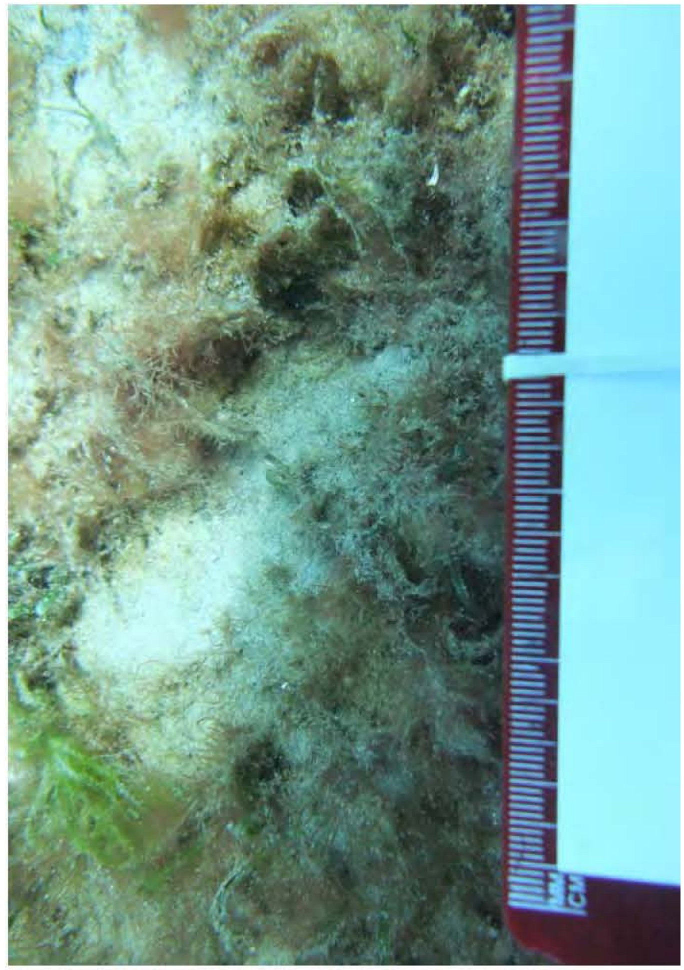
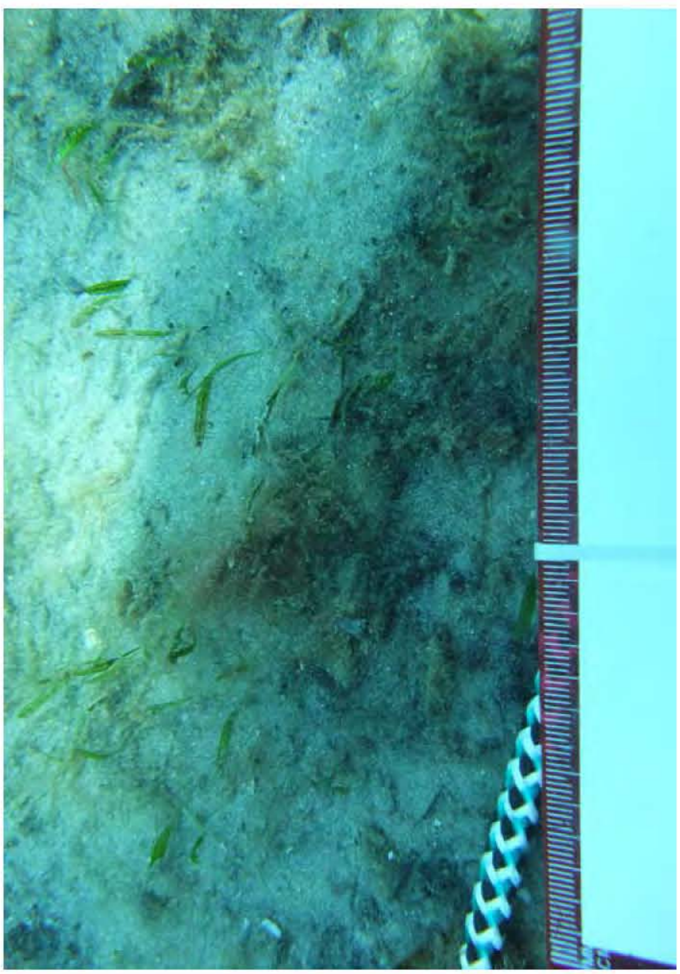


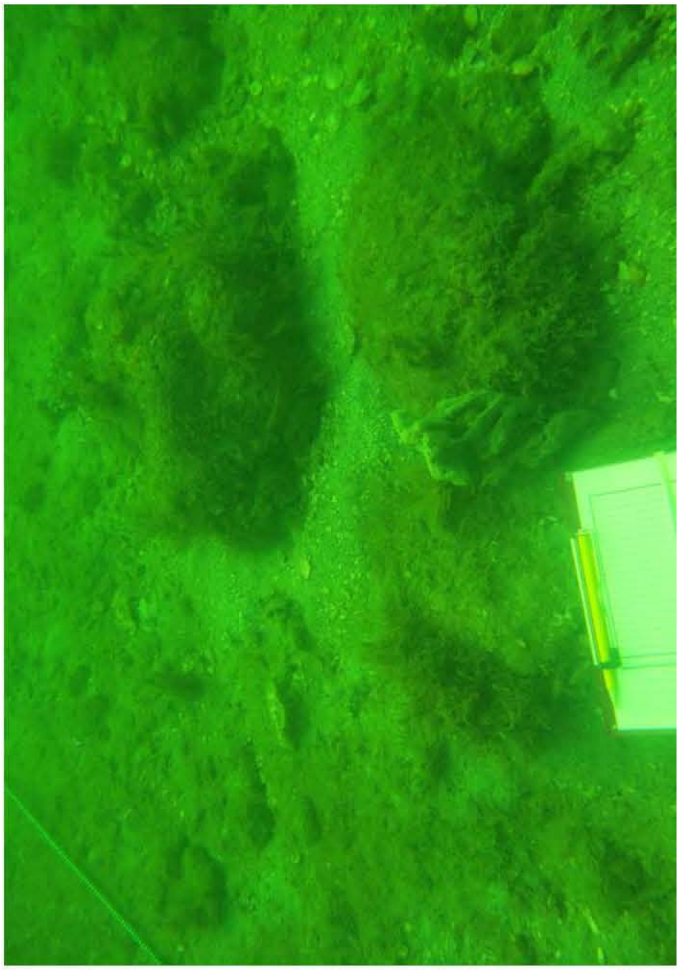
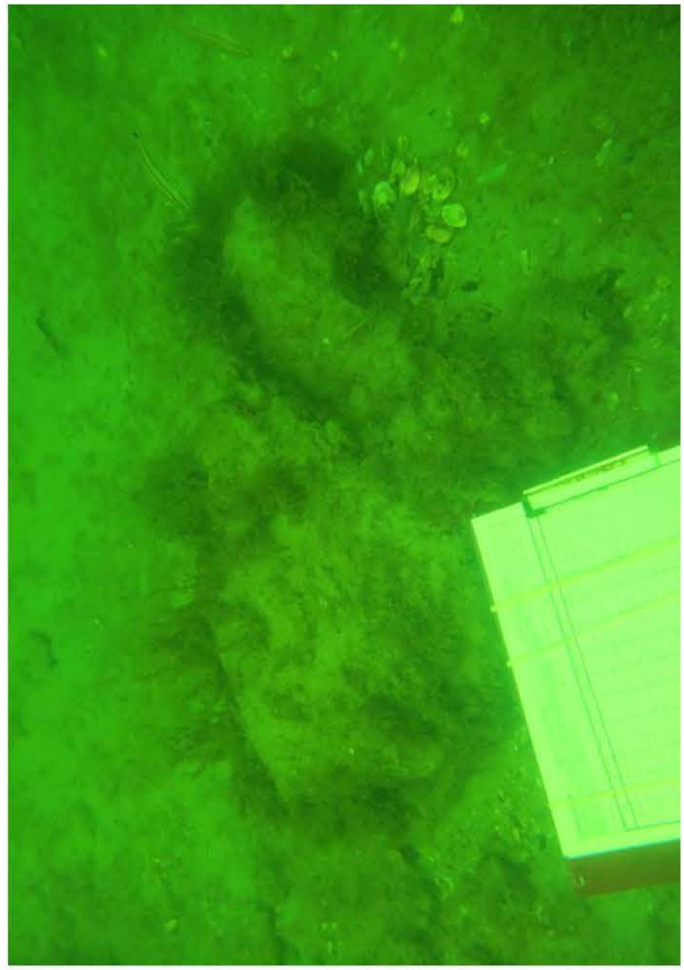



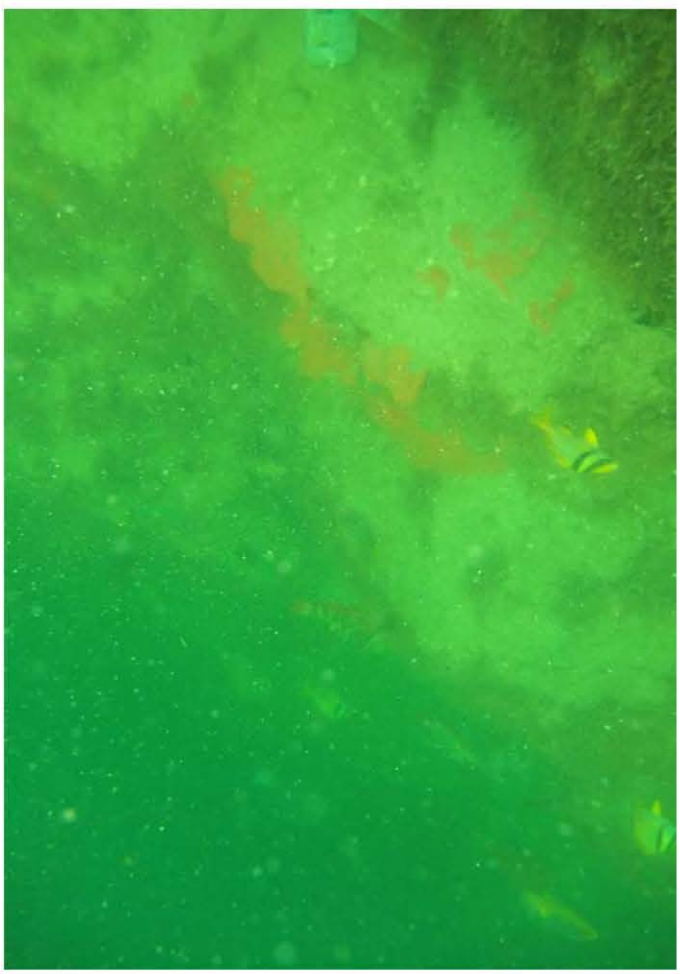


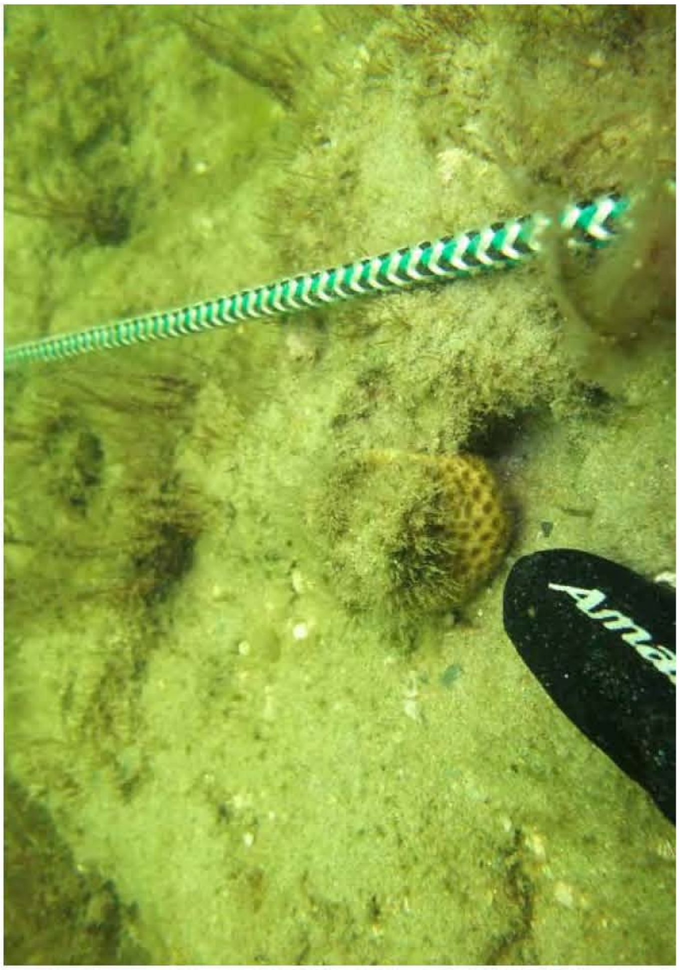
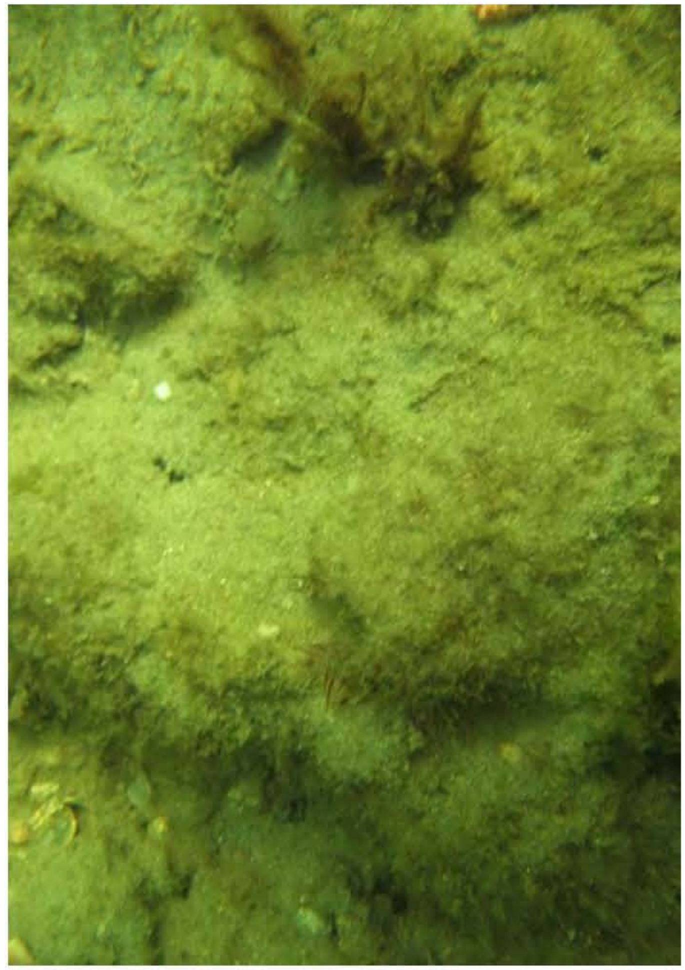
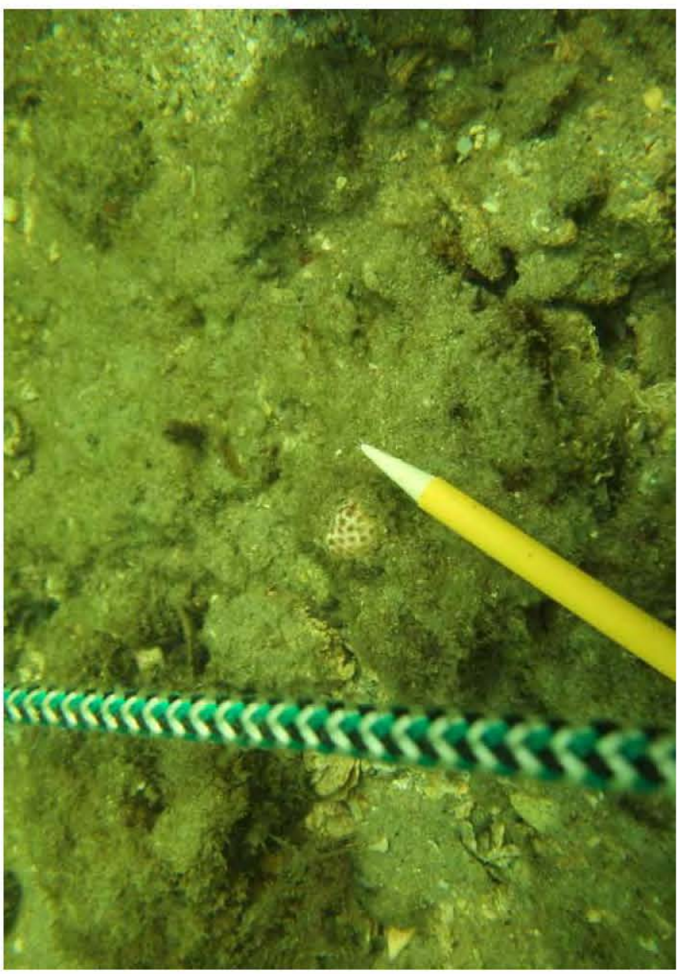
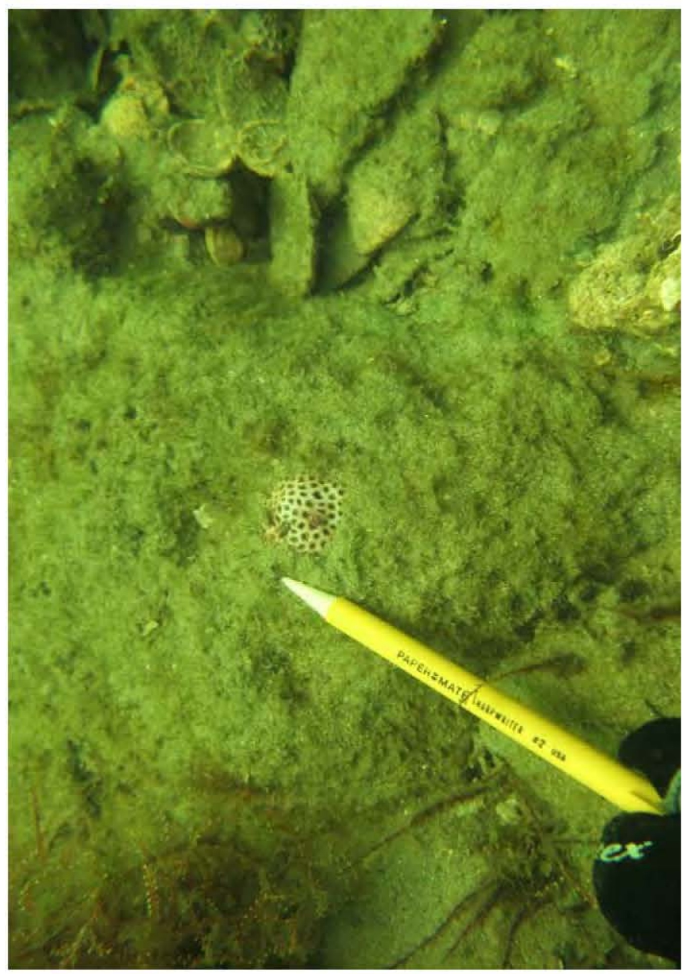


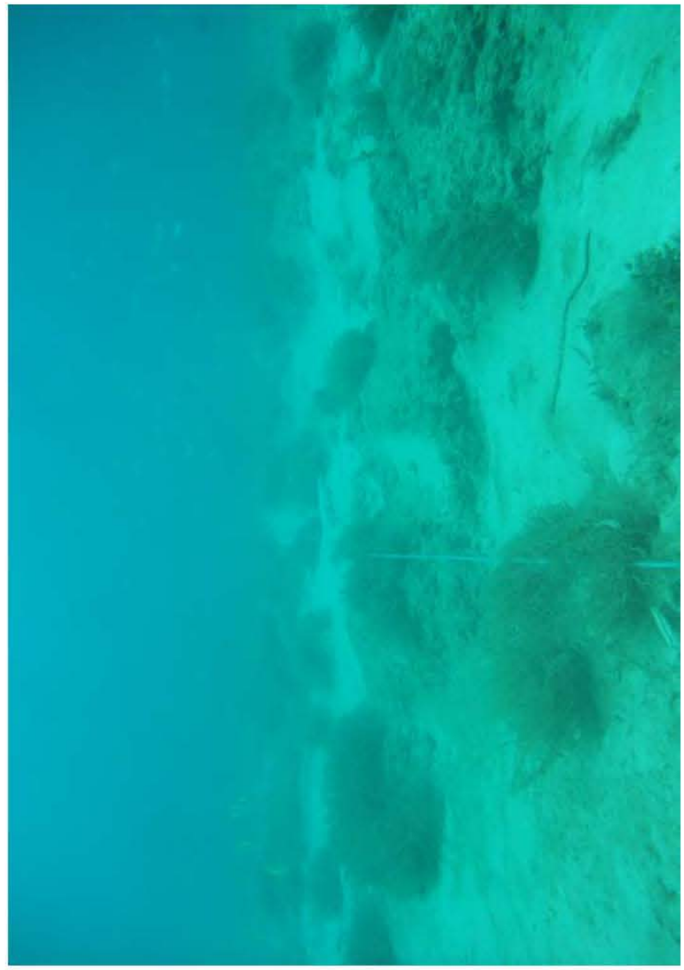
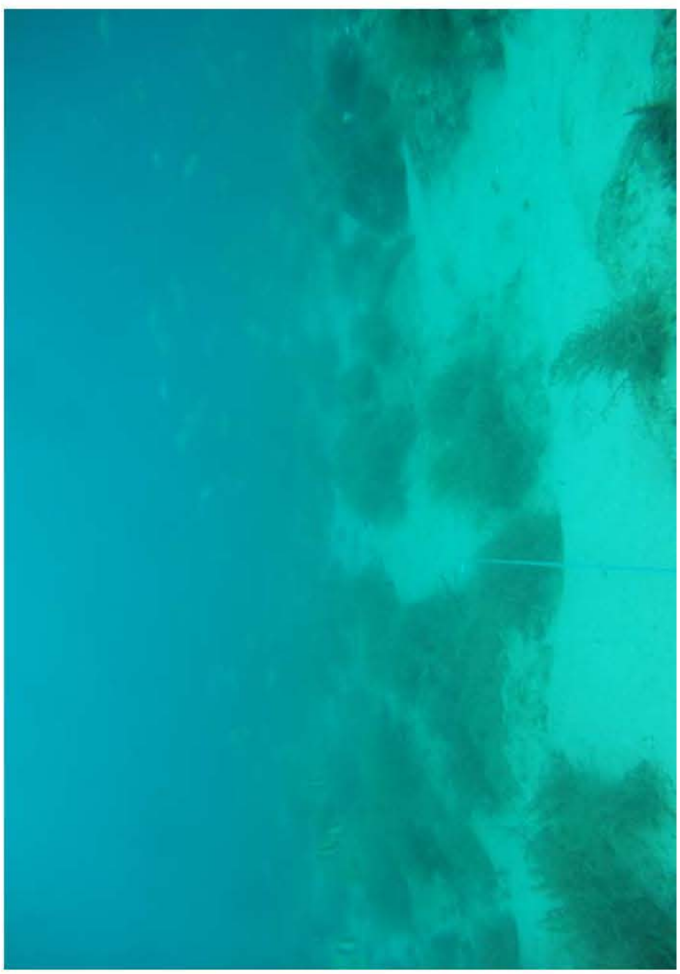
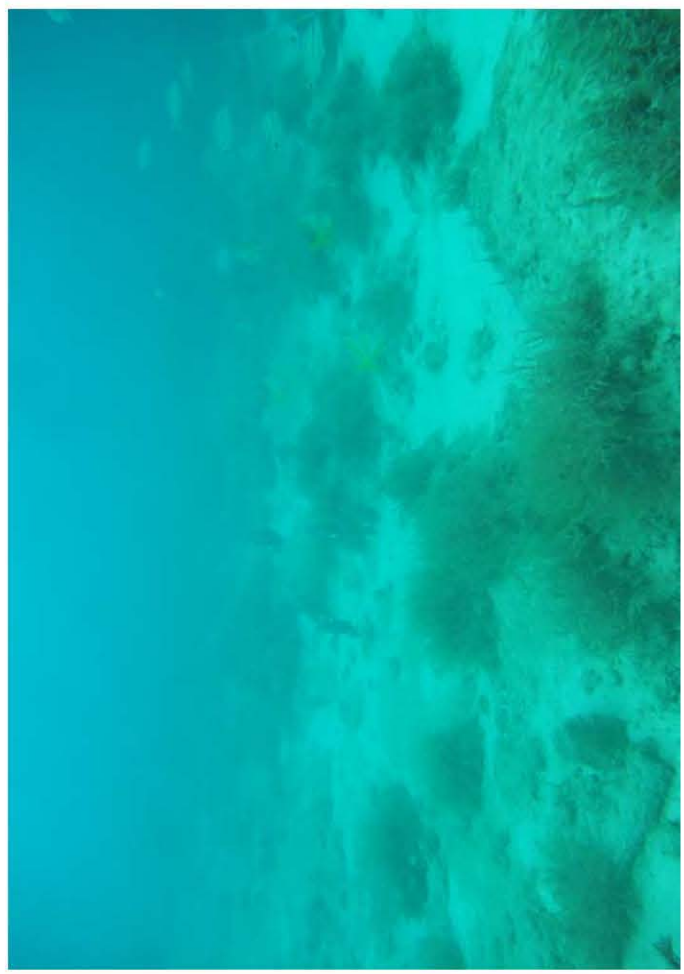



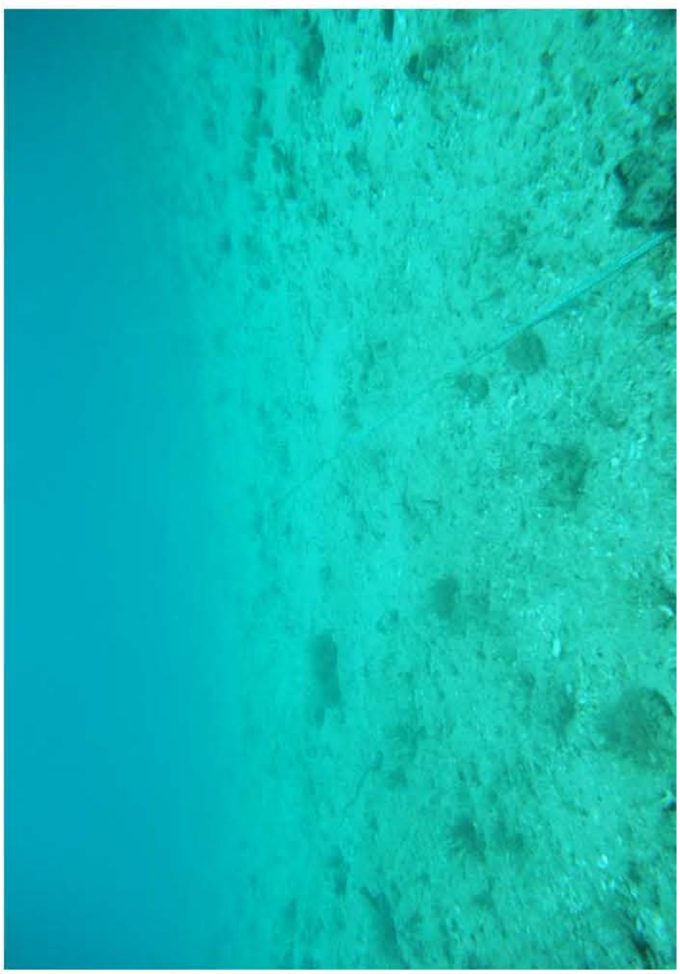

FINAL REPORT

Palm Beach Harbor Navigation:
Feasibility Study
Environmental Resources Report

A complete submerged aquatic resources survey for the Port of Palm Beach,
extending from the 42-ft contour shoreward.
Conducted June-October 2008.

Submitted to:	Ardaman & Associates, Inc. 2200 North Florida Mango Rd., Ste 101 West Palm Beach, Florida 33409
Copies to:	Port of Palm Beach
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January 2009

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1.0 Introduction

The U.S. Army Corps of Engineers (USACE) required a report on the current environmental conditions within the area of the Port of Palm Beach (PoPB) as a part of the Feasibility Study for port expansion alternatives. The Port of Palm Beach District agreed to move forward with the environmental resources survey and report as a part of the feasibility study for proposed modifications to the PoPB. PBS&J was subcontracted by Ardaman & Associates, Inc. to conduct an environmental resources survey for the potential expansion and deepening alternatives.

This environmental resources survey integrates historical data, collected during an expansive literature review, preliminary agency coordination and the results of numerous field surveys, conducted via diver and towed video during the summer and fall of 2008. These data were used to map and characterize the benthic habitats of the PoPB from the 42-ft contour shoreward to the western-most bulkhead, including all areas of potential impact and an additional 150-ft buffer (750-ft buffer offshore).

To encompass the proposed alternative footprints, the environmental resources survey of 2008 included an extensive diver survey of eight proposed expansion zones and towed video documentation of the existing federal channel, turning basin, and berths **(Figure 1)**.

Figure 1. General location map for the Environmental Resources Report study area. Diver-investigated zones A-1 thru G (blue) with a 150-ft buffer (gray). Note the offshore 750-ft buffer (A-1 and A-2). Towed-video transects through the federal channel, turning basin, and existing berths are depicted in gold.

1.1. Project Description

The objective of the environmental resources survey and report was to document, based on existing information and field surveys, the marine, wetland, and terrestrial habitats and associated biological communities within the PoPB. Marine habitat types were to include seagrasses, hardbottom, and reef communities.

1.2. Project Background[i]

The PoPB is located 80 miles north of Miami and 135 miles south of Port Canaveral. The PoPB is the fourth busiest container port in Florida and the eighteenth busiest in the continental United States. In addition, the PoPB is a major nodal point for the shipment of bulk sugar (domestic usages), molasses, cement, utility fuels, water, produce, and breakbulk items. In its current state, the PoPB provides operating drafts of -32 feet mean low water (MLW) for vessels up to 700 feet in length. A turning basin measuring 1,540,000-ft^2 provides a safety margin for the cruise and cargo vessels that access the harbor on a daily basis.

Currently, however, larger, more modern vessel types are experiencing delays and incurring increased operational cost due to the limitations of now out-dated harbor dimensions.

The USACE's 2001 Expedited Reconnaissance Report concluded that, based on preliminary findings, there was a federal interest in pursuing improvements to the PoPB. Potential improvements included widening of the outer entrance channel, jetty realignment, widening and deepening the inner entrance channel, and enlarging and deepening the turning basin. In August 2005, the Port of Palm Beach District and USACE executed an agreement to partner in a Feasibility Study to further define the federal interest in harbor expansion. The Palm Beach Harbor Navigation Feasibility Study will assess the costs and benefits associated with improvements to the federally-designated deep water channel and turning basins serving the PoPB. The complete study will analyze alternatives to improve access for the existing fleet and to allow for vessels of increased length/draft while avoiding or minimizing impacts to environmental resources. The study was stalled when a federal appropriations bill was not passed by Congress in 2006; however, a modification to the agreement allowed the study to begin using the Port's funding share. The first National Environmental Policy Act (NEPA) Scoping Meeting was held on January 9, 2008 to provide for public information about the Study and to solicit input on issues and concerns regarding its scope.

[i] Information presented in Project Background was obtained from the Port of Palm Beach website http://www.portofpalmbeach.com/about_us.htm

2.0 Technical Approach

The following section presents the technical approach utilized to document the seagrass, hardbottom, and coral reef communities within the study area. Field surveys were conducted between June and October 2008.

Subsurface conditions at the survey site varied greatly and were largely dependent upon tidal stage, mean wind field, and recent precipitation. Maximum tidal currents ranged from 2-4 knots, with flood tide generally running northerly and ebb southerly across the Lagoon. Tidal ranges were relatively small (< 1-m); however, marked differences in water clarity between tannin-rich Lake Worth Lagoon and the comparatively oligotrophic Atlantic waters were observed, leading to widely varied visibility (2 to 20+ m horizontal).

To mitigate these conditions, all diving operations were suspended during times of high current flow and/or minimum horizontal visibility and all field deployments were scheduled so as to maximize the slack high water available during daylight hours. These strategies consistently provided our field biologists with exceptional visibility, greatly enhancing resource identification, even at great distances. The methodologies described below represent best possible efforts toward reconciling a challenging worksite with the rigors demanded by NMFS/NOAA survey methods, particularly those for *Halophila johnsonii* (Johnson's seagrass; National Marine Fisheries Service 2002).

2.1. Seagrass Community Assessment

All submerged lands within the expansion zones C, D, F, and G (including the 150-ft buffer) were intensively sampled for seagrass occurrence, composition, and density by divers on SCUBA using the latest in GIS technology. The objectives of the seagrass survey were (1) to produce a detailed, species-specific map capable of estimating impact acreage, (2) to quantify the distribution of *Halophila johnsonii* within the expansion area, and (3) to estimate the density of seagrass occurrence within the surveyed area.

2.1.1. Roving Diver Survey

Each zone-specific seagrass survey began with a 2-hr (minimum zone^{-1}) roving diver reconnaissance whereby 2-4 biologists swam the survey area using SCUBA or snorkel. All biologists that contributed to this evaluation have extensive experience with working under the conditions within the PoPB as well as in the identification of all species that were encountered during the field reconnaissance. Dives were completed within the established dive program which has been certified by the American Academy of Underwater Sciences (AAUS). All areas containing seagrasses were noted, located with GPS (Garmin 76CSx) and, where necessary, marked with temporary buoys (6-inch trap floats). These observations provided a general overview from which diver entry and extraction points were informed and subsequent dive plans were set (Section 2.1.2).

2.1.2. Seagrass Habitat Mapping

Species-specific seagrass habitat maps were produced by biologists on SCUBA using the latest in GIS technology. A Trimble Geo-XT handheld DGPS unit, running ArcPad 7.0, was used onboard a 24-ft Godfrey Sweetwater pontoon boat to record diver position as the exterior edges of seagrass beds were swum. Polygonal contour vertices were identified by divers in the water and signaled to the boat by means of a tethered buoy. Successive polygons were then added to the shapefile until the entire zone had been sufficiently mapped. Confirmation of this was achieved by a post-mapping reconnaissance similar to the diver survey described in Section 2.1.1, and included numerous cross-bed transects (near-random) to ensure the continuity of species or multi-species assemblages.

Wherever possible, divers worked with the prevailing current and took advantage of the 20+ m of horizontal visibility to identify and track the edge of seagrass habitat within each zone. Typical search patterns involved one diver holding the existing edge with another diver surveying down-current for the next significant vertex. Due to the diffuse and temporally dynamic nature of *Halophila* spp. bed formation (the predominant genera onsite at the time of survey) a unique working definition for 'edge of bed' was adopted to ensure that all existing and imminent habitat space was mapped. Gap spaces of up to 5-m were permissible under this definition, if substrate conditions (i.e., presence of diatom mats, adequate grain size, and absence of sand waves) remained suitable between adjacent *Halophila* patches. In this manner, patches under the operational error of the method, estimated at roughly 2-m diameter, and the full scope of spatial variance exhibited by individual *Halophila* patches over intermediate timescales (i.e., within one growing season) could be adequately represented in the final distribution map.

All diver surveys were discontinued within the existing turning basin, navigation channels, and at depths greater than 10.7-m (35-ft).

2.1.3. Seagrass Coverage

To estimate the percent coverage of seagrasses within the survey area, 1-m^2, PVC quadrats, divided into 100 equal cells, were assessed for (1) the number of cells containing each species and (2) the total number of seagrass-containing cells. Divers entered up-current of previously delineated beds and placed successive quadrats at a down-current spacing of 5 to 10 blind fin kicks. DGPS locations were recorded for each quadrat with a Trimble Geo-XT handheld unit using the signaling protocol described previously (Section 2.1.2). Resultant species-specific coverage data were appended to a point-shapefile in ArcGIS 9.2 and subsequently analyzed.

2.1.4. Analysis and Interpretation of Seagrass Data

Spatial analysis of field-collected distribution data was performed using ESRI's ArcGIS 9.2 software. Polygonal features, representing seagrass habitat, were clipped to survey boundaries, assigned a unique species name or combination of names, and areal cover was calculated in ft^2, m^2, and acres. Point data, representing quadrat locations and percent cover estimates, were clipped to delineated bed boundaries and further assessed for inter- and intra-zonal trends.

Quadrat data were further used to confirm the species designations assigned to patches/beds identified in Section 2.1.2.

2.2. Hardbottom and Reef Community Assessment

Coral reef and hardbottom habitat was assessed and mapped within areas A-1, A-2, B-1, B-2, and C. The objective of the field survey was to produce a detailed map of coral reef and hardbottom habitat that would allow for future estimation of impact acreage. In addition, offshore surveys were conducted to determine the presence of *Acropora* spp. in areas of potential occurrence (Expansion Zones A-1 and A-2). To ensure safe operation in a busy recreational and commercial inlet and harbor, all underwater investigations were conducted within limitations set by tide, current, wave energy, weather, and shipping traffic.

2.2.1. Habitat Mapping

Hardbottom surveys began with a 2-hr (minimum zone^{-1}) roving diver reconnaissance whereby 2-4 biologists swam the survey area using SCUBA or snorkel (excluding expansion zones A-1 and A-2). All areas containing hardbottom habitat were noted, located with GPS (Garmin 76CSx) and, where necessary, marked with temporary buoys (6-inch trap floats). Subsequent dives were made to map the contours of the hardbottom portions of C, B-1 and B-2 using a Trimble Geo-XT DGPS handheld unit, running ArcPad 7.0. The general protocol followed that described in Section 2.1.2; however, the polygon shapefile produced in this manner was not appended with internal observation, as additional diver video would later be analyzed for benthic composition (Section 2.2.2).

2.2.2. Handheld Video

Handheld underwater video was recorded in areas B-1, B-2, and the hardbottom portion of C for qualitative and quantitative analysis of benthic components. Video was also collected in the hardbottom portions of D and G for qualitative analysis only. All video was shot using a Sony DCR-VX2000 in progressive scan mode and recorded on 6 Sony DVM60PRL Premium MiniDV 60-minute cassettes. Divers swam slowly, videotaping at a height of 40-cm from the substratum, using a digital video camera in an underwater housing fitted with a wide-angle lens and underwater video lights. A depth gauge and scaling bar were attached to an aluminum bar that projected forward from the video housing. The gauge and bar ensured that the camera remained a constant distance from the bottom. By holding the video camera perpendicular to the substratum, swimming slowly, and filming in progressive scan mode, it was possible to produce clear stop-action images for analysis. Each video frame covered a 40- x 27-cm area, or 1,080-cm^2 of the substrate. This size is designed to enable investigators to identify corals and many other sessile invertebrates to species down to a colony size of approximately 3-cm.

Diver video included the channel slopes and walls (B-1 and B-2), the expansion areas outside of the existing ship channel (hardbottom portion of C), and the slopes of the existing turning basin (hardbottom portions of D and G). To more precisely delineate the habitat type and orientation of the substrate within each expansion zone, subdivisions were assigned as follows for C: C (horizontal) and CWALL (vertical); B-1: BS1 (horizontal), BS2 (vertical); and B-2: BN1 (horizontal) and BN2 (vertical). These distinctions, along with the interpolated dive coverage (i.e., the straight-line distance from entry and exit points) for all handheld video dives can be seen in **Figure 2**.

Figure 2. Dive location and interpolated distance (i.e., the straight-line distance from diver entry and exit points) for all handheld video shot within previously delineated hardbottom habitat.

To quantitatively describe the benthic composition of major functional groups, non-overlapping frames were captured from the diver video using ULead® VideoStudio® 9. After image capture and enhancement using ULead® digital filters, randomly located dots were added to each frame using Coral Point Count® (CPCe). Organisms positioned beneath each random dot were identified to the major group level (**Appendix A**). After each image was analyzed, the data were entered into project-specific Microsoft Excel spreadsheets.

To determine the dot-density needed for an adequate characterization, a single dive sequence consisting of 37 images was repetitively analyzed using successively greater dot densities (10-50 dots per image) and assessed for species accumulation. The resulting rarefaction curve is depicted in **Figure 3**. From this process, a final number of 25 dots image^{-1} was selected for further use.

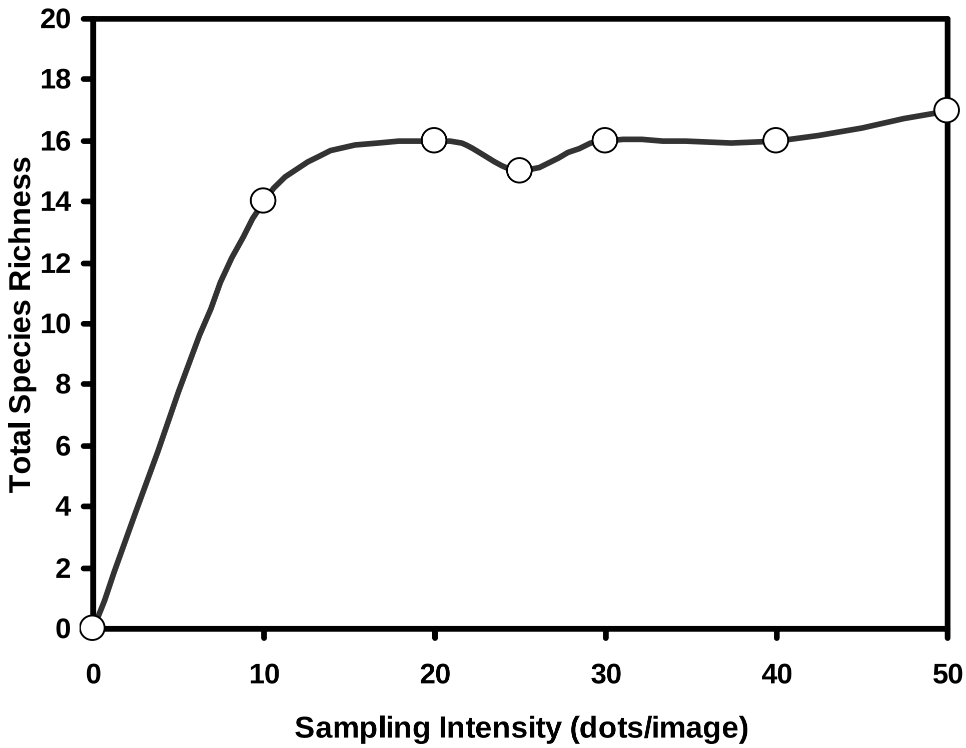


Figure 3. Species accumulation curve for 37 images repetitively analyzed using CPCe (10-50 dots per image).

2.2.3. Acroporid Survey

Expansion zone A-1 (**Figure 1**) was sampled for *Acropora* spp. using the National Marine Fisheries Service (NMFS) "Recommended Survey Protocol for *Acropora* spp. in Support of Section 7 Consultation". The objective of this survey was to determine the distribution and abundance of *Acropora* spp. within the near offshore area.

The diver survey consisted of multiple dives on September 22, 2008, during which time, 2-4 biologists covered the areas of potential hardbottom identified during the towed video surveys (Section 2.3) **(Figure 4)**. *Acropora* spp. surveys were also conducted at multiple centroid locations within expansion zone A-1 (8 sampling sites; A-2: 0 sampling sites) **(Figure 4)**. To define these areas, a 750-ft buffer was placed around those portions of A-1 and A-2 that had less than 42-ft depth (as indicated by Palm Beach Co. LADS imagery) and were previously reported as colonized hardbottom (FDEP/SEFCRI 2007). If hardbottom/survey sites identified from towed video were in the same vicinity as the generated centroids of the 10,000-m^2 cells, only one of the two sites was surveyed. A total of eight survey sites were visited for the *Acropora* spp. survey. General observations and photographs were taken to further characterize the hardbottom habitat at each survey site.

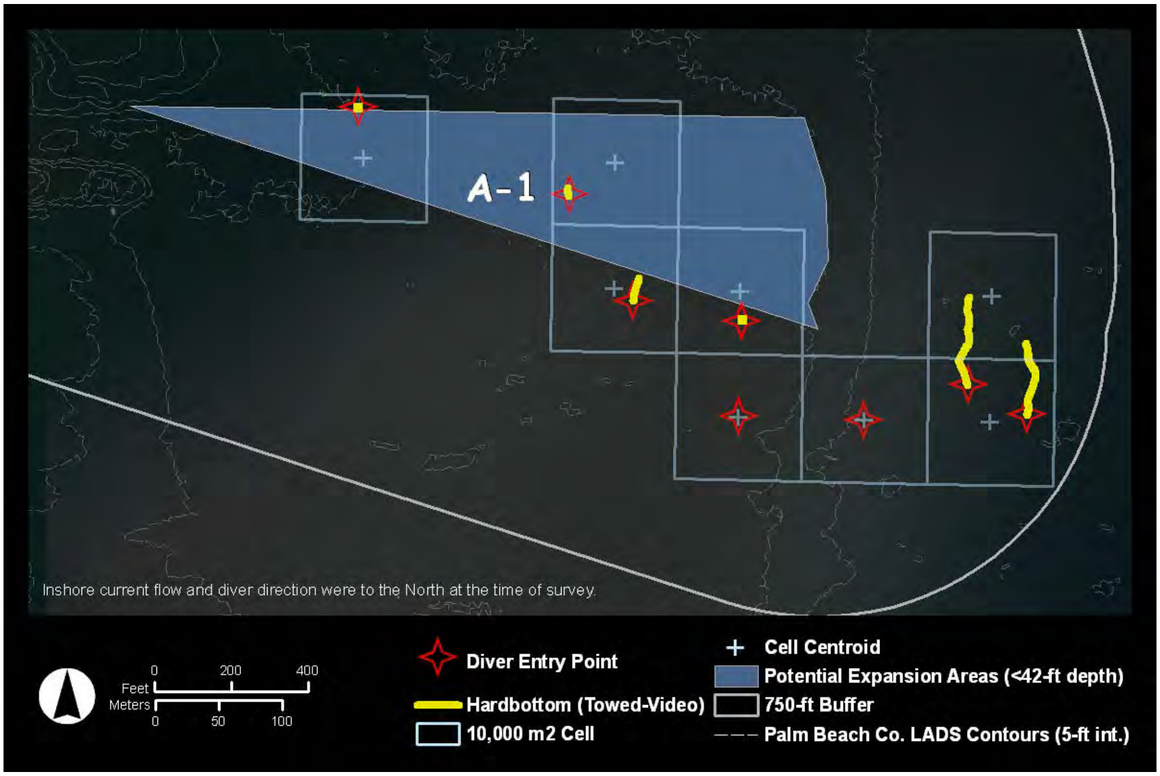


Figure 4. The locations of Acroporid surveys within expansion area A-1.

If *Acropora* spp. colonies were observed, the following data would have been collected for each colony: (1) species, (2) single largest linear dimension of the colony (mm) or length, width, and height, (3) rank of percentage live tissue (i.e., < or > 50%), (4) GPS coordinate of each colony or each survey site, and (5) site map with locations of each colony. If > 5 colonies of *Acropora* spp. were encountered, PBS&J scientific divers would have laid 3 belt transects from the referenced center point at 3 random bearings. Each belt transect would have measured 4-m x 50-m, for a total of 200-m^2. The aforementioned data (points 1-5) would have been collected for each colony observed along the transect.

2.2.4. Analysis and Interpretation of Hardbottom Data

Spatial analysis of field-collected distribution data was performed using ESRI's ArcGIS 9.2 software. Polygonal features, representing hardbottom habitat, were clipped to survey boundaries. Areal cover was then calculated in m^2 and in acres. Percent cover estimates for major functional groups were summarized by subzone (defined in Section 2.2.2) and factor plots (mean +/- SE) of individual taxonomic groups were used to assess general trends.

2.3. Towed-Video Investigation

A towed video system was utilized on July 23-25, 2008 to map areas A-1, A-2, C, the turning basin, the commercial ship channel, and the ship berths. The towed camera was deployed from the Survey Vessel *Howard Post*, a 25-ft. aluminum workboat. Horizontal positioning of the survey boat and camera was accomplished using Hydropro 2.1 navigation software and a Trimble Ag132 global positioning system (GPS) equipped with a US Coast Guard differential correction receiver. The navigation software was configured to log data from the GPS at 1-second intervals.

The video system consisted of a video camera, two lights, an altimeter, a hydrodynamic PVC tow body, and an electrical cable tethering the system to the boat. A RemoteOceanSystems (ROS) MCZ color zoom camera was mounted on the underside of the PVC tow body and pointed downward along the vertical axis. The camera image encompassed a field of view in water measuring 31.8º (horizontally) by 24.4º (vertically). Video imagery (PAL format) was recorded on a Viperfish MSX digital video recorder in Windows AVI format at 25 frames per second with a resolution of 720 x 576 pixels. Kongsberg underwater lights were mounted forward and aft of the camera. An Oceantools MA500 altimeter, with millimeter accuracy, was mounted forward of the camera in order to provide a real-time input regarding the altitude of the camera lens above the seafloor. Digital data feeds from the altimeter and GPS coordinates were overlain on video imagery using an Oceantools VO4-W video overlay system. The average speed of the *Howard Post* while collecting video was 0.9 knots. The height of the video camera off bottom was maintained at 0.5- to 1.0-m. All lateral distance measurements were calculated in ArcGIS using the aforementioned GPS data.

Table 1 lists the proposed and actual number of transects collected by towed video for areas A-1, A-2, C, the turning basin, the commercial ship channel, and the berths. GPS coordinates of the proposed transect locations were used by the survey vessel *Howard Post* to collect the towed video. Because of weather, high current conditions, berthed ships, and heavy commercial and recreational boat traffic, it was occasionally deemed impractical to exactly follow the proposed transect alignment.

Table 1. Proposed and actual number of transects collected with towed video in expansion zones A-1, A-2, C, turning basin, commercial ship channel, and ship berths.

Expansion Zone	Proposed Number of Transects	Number of Transects Collected
A-1	18	18
A-2	19	19
C	26	26
Turning Basin	28	27
Channel	2	1
Berths	16	6

2.3.1. Analysis and Interpretation of Towed Video Data

All towed video collected in expansion zones A-1, A-2, C, turning basin, commercial ship channel, and berths was qualitatively analyzed for hardbottom or submerged aquatic vegetation (SAV). Start/stop data (latitude and longitude) were obtained from the georeferenced video for both SAV and hardbottom habitats. These XY data were transmitted as a table and converted to a shapefile in ArcGIS. Single points in the shapefile indicate single instances of hardbottom/SAV whereas lines represent continuous hardbottom features/seagrass beds.

3.0 Environmental Resources

3.1. Seagrass Communities

3.1.1. Results

Seagrass habitat was documented in 4 zones: C, D, F and G (**Figure 5**). Subsequent analysis and discussion combines zones C and D, as well as F and G, in order to reduce potential confusion caused by overlap of adjacent 150-ft buffers. The resulting zone pairings, hereafter 'C&D' and 'F&G', covered a total of 548,364-m^2 or 135.50 acres (C&D: 209,920-m^2; F&G: 338,444-m^2). An estimated 18.05% of this or 24.46 acres (98,997.15-m^2) was determined to be seagrass habitat. The habitat consisted of 83 monospecific and multispecies patches (C&D: N=27; F&G: N=56), typically composed of *Halophila johnsonii*, *H. decipiens*, or *Halodule wrightii*, although *H. decipiens* tended to predominate where found. Patch size ranged from < 1-m^2 to 46,535-m^2 with a mean value of 1,306.61 +/- 596.36-m^2 (here and throughout, Mean+/-Standard Error). Species-specific coverage as well as intra- and inter- zonal trends are discussed in Section 3.1.2 (below).

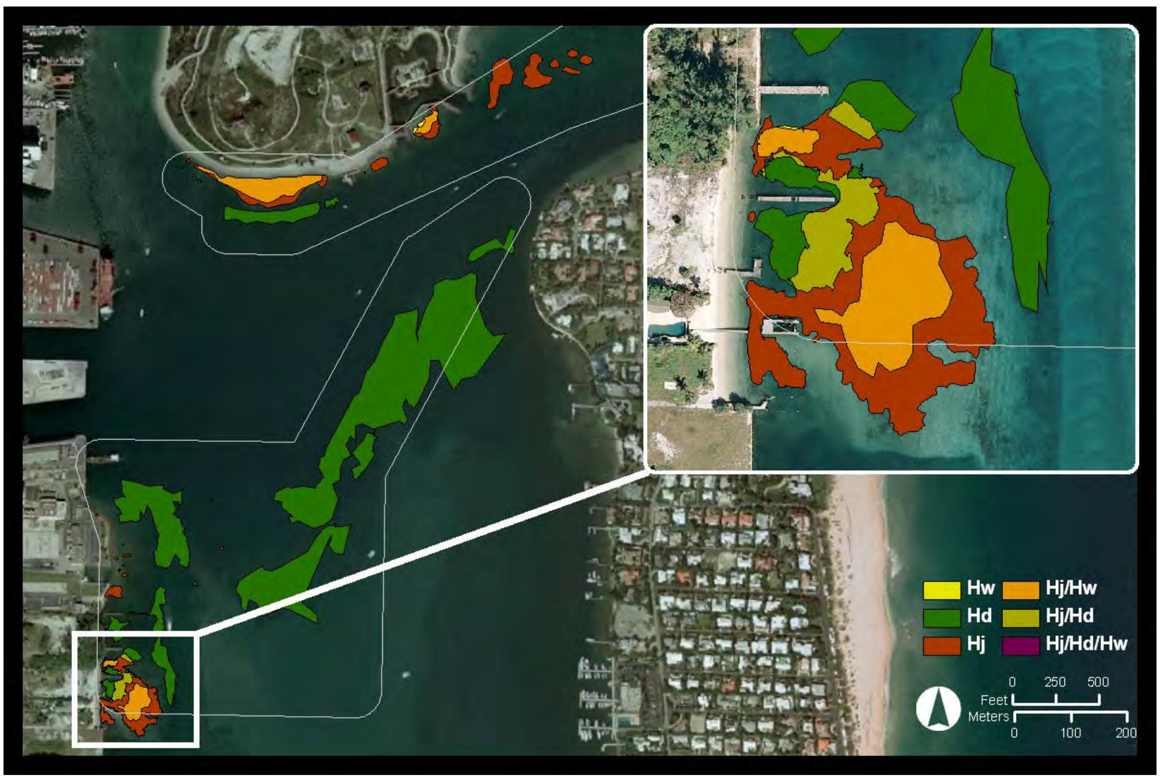


Figure 5. Location of seagrass habitat within the PoPB seagrass survey area. Zones C&D (north) and F&G (south) contained 8.61% and 23.91% seagrass habitat, respectively. Percentages based on separate zone boundary combinations.

3.1.2. Distribution

Seagrass habitat varied in the extent of aerial coverage and in the species composition of delineated patches, both within and among zones. F&G supported nearly an order of magnitude more seagrasses than C&D with 19.99 acres (80,916.01-m^2) found south of the existing Federal Channel and 4.47 acres (18,081.14 m^2) to the north (**Table 2)**. Monospecific meadows tended to dominate the benthos of both zones; however, multispecies assemblages comprised a significant proportion of C&D with 1.52 acres of *H. johnsonii* and *Halodule wrightii* mixed assemblages accounting for roughly 34% of seagrasses in that zone. Other inter-zonal trends included a greater coverage of *H. johnsonii* in C&D relative to F&G, with 1.32 additional acres (C&D: 3.42 and F&G: 2.10 total acres), and substantially more *Halophila decipiens* (18.21 acres) south of the Federal channel (F&G) relative to 1.01 acres in C&D.

Table 2. Calculated patch size by species and zone combination. Seagrass polygons were clipped to zone boundaries prior to analysis.

Zones C & D			
Species	**N**	**Area (m2)**	**Acre**
Hd	7	4,069.76	1.01
Hj	15	7,679.32	1.90
Hj/Hd	0	0.00	0.00
Hj/Hd/Hw	0	0.00	0.00
Hj/Hw	3	6,161.59	1.52
Hw	2	170.47	0.04
Subtotal	27	18,081.14	4.47

Zones F & G			
Species	**N**	**Area (m2)**	**Acre**
Hd	18	72,399.90	17.89
Hj	23	5,146.70	1.27
Hj/Hd	8	1,281.94	0.32
Hj/Hd/Hw	1	1.29	0.00
Hj/Hw	2	2,077.08	0.51
Hw	2	9.11	0.00
Subtotal	54	80,916.01	19.99
Total	**81**	**98,997.15**	**24.46**

Intra-zonal trends in the distribution of species and patch-types appeared to be driven largely by depth and current flow. Shallower portions of zones (i.e., less than 3-m) were dominated by *H. johnsonii* interspersed with patches of *H. wrightii*, often at low density (see below). This was particularly evident in C&D (**Figure 6)** but was also seen in the southwestern portion of F&G (**Figure 7**). Deeper sections (>3-m) tended to support large expanses of *Halophila decipiens*, as dictated by substrate conditions; e.g., sufficient grain size and distance from migrating sand ripples. *H. decipiens*, particularly on the north-facing slope of F&G, was frequently found at depths exceeding 10-m. A fruiting event was recorded for *H. decipiens* in the shallower beds of the southwest portion of F&G on August 7, 2008 (Percent Cover Quadrat #378, **Figure 8**), indicating the reproductive health and productivity of the area for this species.

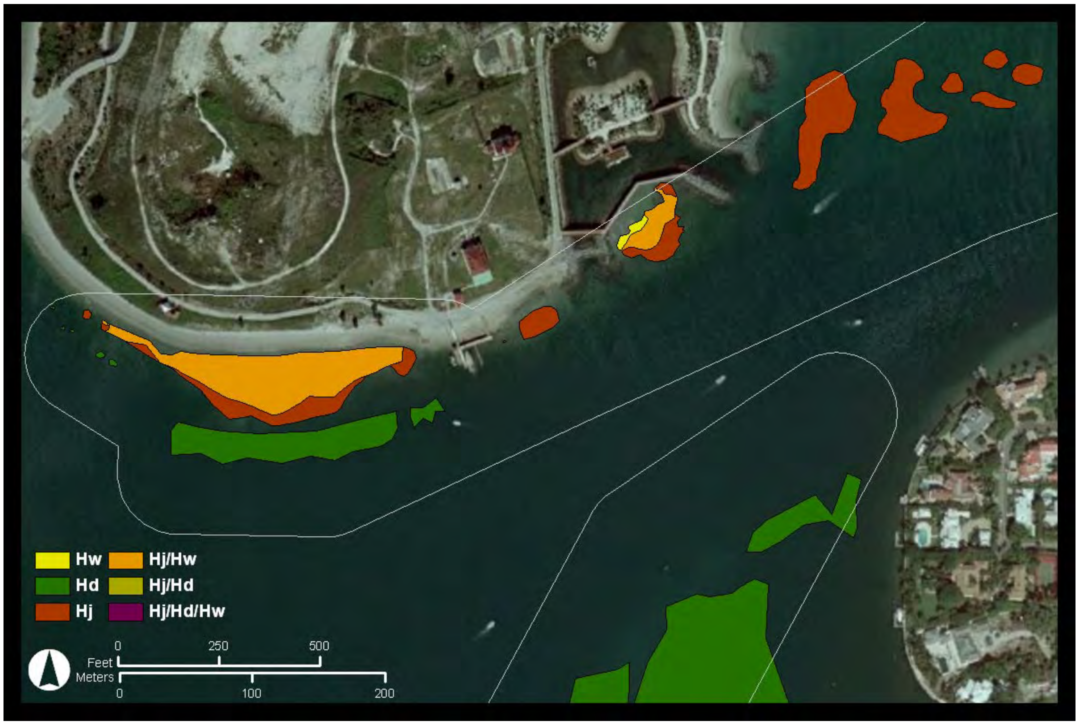


Figure 6. Location of seagrass habitat within Zones C&D. Polygonal features were located and mapped by biologists during the diver survey.

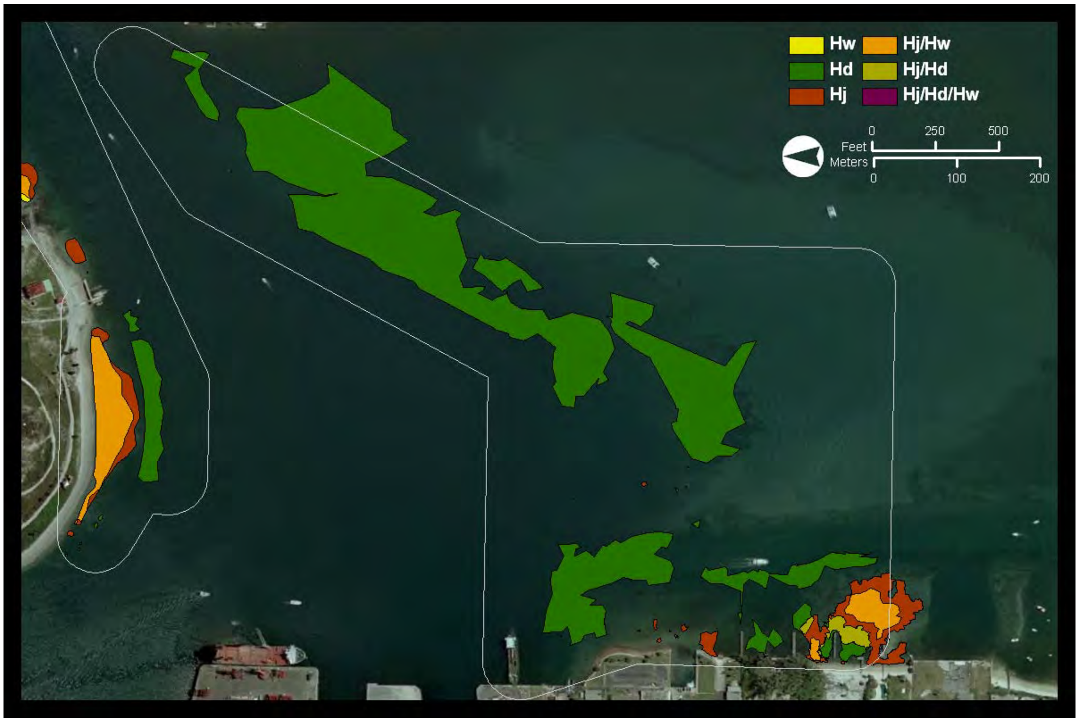


Figure 7. Location of seagrass habitat within Zones F&G. Polygonal features were located and mapped by biologists during the diver survey.

Figure 8. Photo documentation of the *H. decipiens* fruiting event observed on August 7, 2008. Image taken from quadrat #378 in Zone G. Red, dashed circles highlight visible fruits.

Representative photography was taken at most quadrat locations used in the percent coverage estimates, detailed in Section 3.1.3. A subset of these archived images, representing locations interspersed throughout the survey area, can be seen in **Figure 9.** Note the occurrence of dense *H. johnsonii* in the western portion of C, the large monospecific beds of *H. decipiens* within F&G, and the general clarity of the overlying water column throughout.

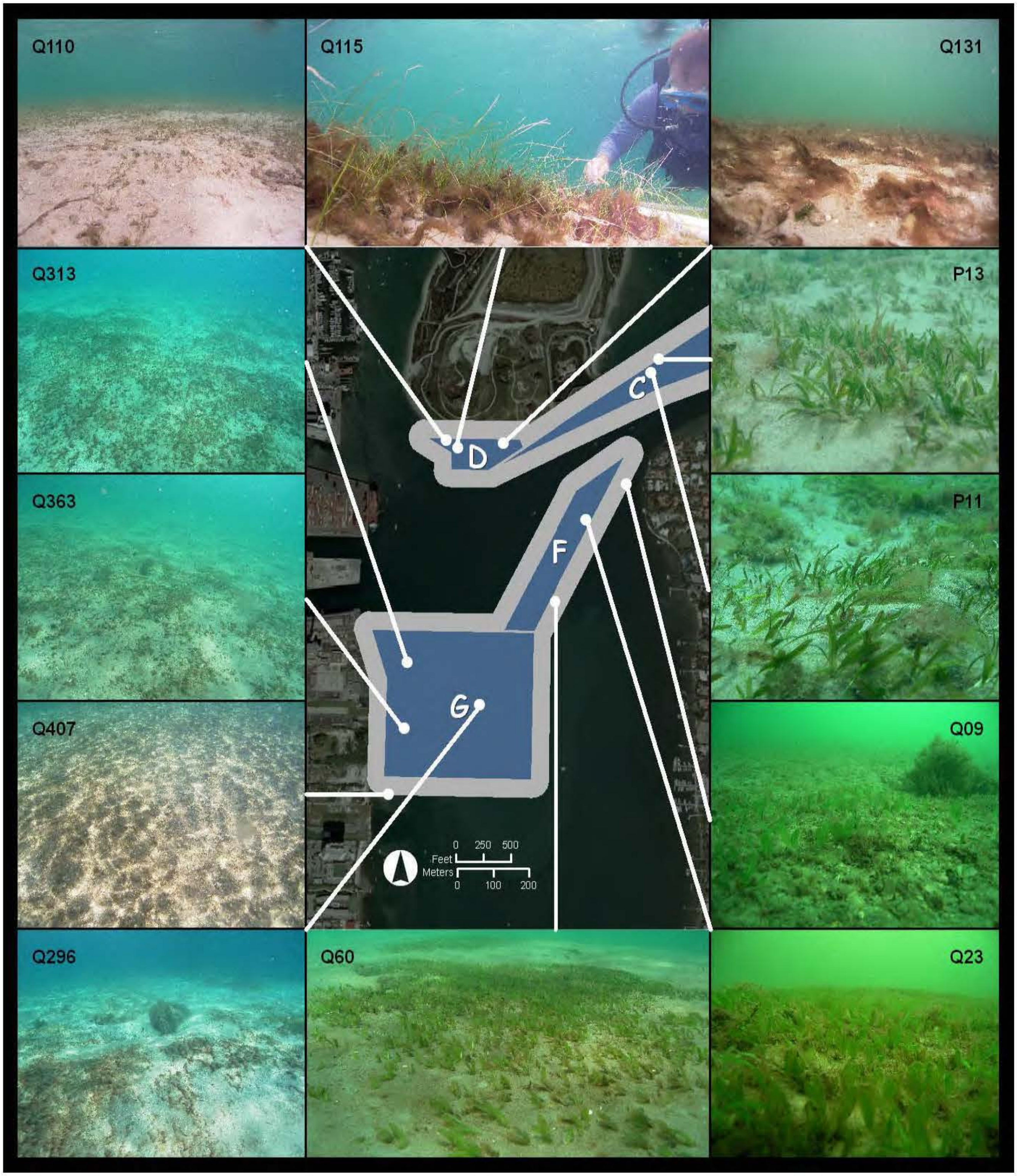


Figure 9. Representative photography from locations interspersed throughout the surveyed area. Quadrat numbers (Q) reference locations where density estimates were made. Photographic point numbers (P) indicate locations where archival images were taken.

3.1.3. Percent Coverage

During the course of the survey, a total of 452 quadrats were assessed for species-specific and total seagrass coverage; 350 fell within patches delineated as seagrass habitat (**Figure 10; Appendix B**). These quadrats provided density estimates for 31of 83 patches, with a focus on the larger beds and mixed meadows, and served as a diagnostic for the diver survey by cross-checking seagrass densities falling outside of the delineated beds, as well as validated individual patch identities (i.e., assigned species composition) through a secondary, quantitative means.

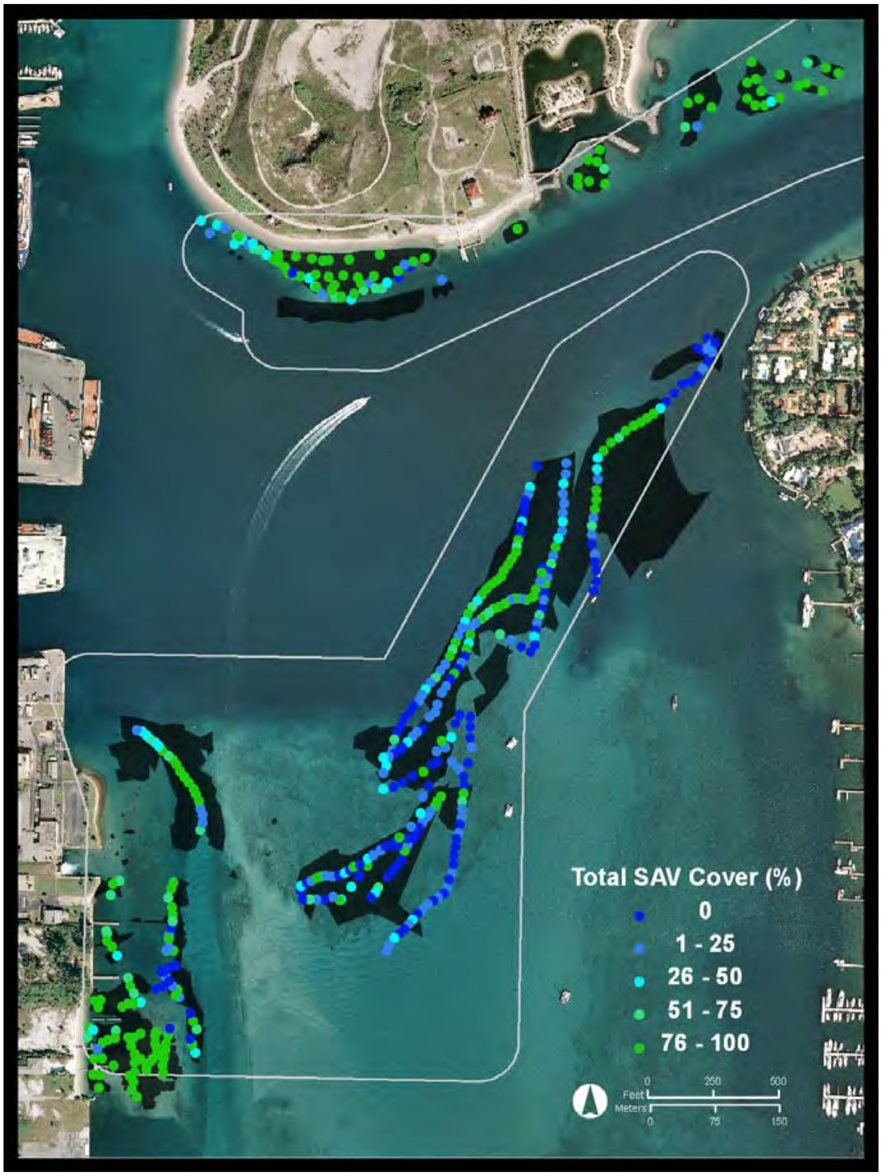


Figure 10. Location of percent coverage estimates conducted during the summer of 2008. Color indicates the percent coverage of total seagrasses within each quadrat.

Diver-delineated patches mirrored internal densities at nearly all investigated locations **(Table 3)**. Wherever quadrat data were present, the species designation comprised more than 96% of the mean total seagrass coverage. This was particularly true of *H. johnsonii / Halodule wrightii* and *H. johnsonii / H. decipiens* patches, where greater than 99% of the mean coverage was correctly identified by divers during the visual survey. Similarly, only 6% of quadrats revealed *H. johnsonii* within a zone not designated as a Johnson's seagrass-bearing assemblage. Overall, there was a strong agreement between patch designation and the constituent species identified by divers during the habitat mapping portion of the survey.

Table 3. Results of percent coverage estimates obtained from previously mapped seagrass habitat. Species designations appear as rows, constituent coverage (+/-SE) values as columns.

		Mean				SE			
	N	HD	HW	HJ	TSAV	HD	HW	HJ	TSAV
All	350	27.47	10.92	23.65	55.09	13.87	6.95	11.52	25.31
Hd	238	39.37	0.00	1.37	40.65	15.65	1.00	2.19	16.05
Hj	66	0.00	9.03	80.67	83.65	0.00	2.96	24.39	28.03
Hj/Hd	3	74.00	0.00	18.00	78.00	6.16	0.00	3.17	7.43
Hj/Hd/Hw	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hj/Hw	43	0.53	75.02	59.88	89.56	1.00	13.45	10.74	25.73
Hw	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Of the 31 patches investigated for seagrass coverage, 14 fell within zones C&D and 17 within F&G. Overall, the effective sampling intensity varied from 1 to 126 quadrats patch^{-1} with a mean value of roughly 11 quadrats patch^{-1}. Mean total seagrass coverage by patch varied from 2 to 100% cover with a survey-wide mean of 75.25% (C&D, 80.29%, F&G, 71.10%). This variability was driven by low sampling intensity in isolated cases; however, spatial variation in the cover of seagrass within designated quadrats often occurred at scales larger than that the of the 1-m^2 quadrats, meaning that quadrats were frequently adjacent to dense cover, especially within *H. decipiens* beds. Therefore, while the mean per patch average was 72.25% and the per quadrat average was 55.09%, the localized density of individual clones were often much greater (as evidenced in **Figure 9**).

Halophila johnsonii densities tended to be greater in C&D, with a mean patch^{-1} value of 73.90%, than in F&G at 65.46%. These numbers were driven largely by the dense *H. johnsonii* beds in the western portion of Zone C and despite the largely contiguous bed of *H. johnsonii* located in the southwestern corner of F&G (**Figures 6 and 7**, but see the inset **Figure 5**). *H. decipiens* patches were only assessed for coverage in F&G, but revealed a mean patch^{-1} cover of 53.04%, a value consistent with total seagrass coverage for the same area and consistent with the patchiness qualitatively described above.

3.1.4. Historical Perspective

Prior to and concurrent with the field investigation, biologists collected and outlined all existing data regarding benthic community composition and submerged aquatic resources within the PoPB area (Lake Worth Lagoon, Fl). These data were compiled in comprehensive GIS deliverable and are made available in **Appendix C**. During the literature acquisition and review stage, all pertinent private, local, state, and federal agencies were solicited for recent and historical data.

The studies most capable of informing our subsequent field efforts were the 1990 *Palm Beach County Submerged Natural Resources Study*, the 1992 *Statewide Seagrass Coverage* survey conducted by the Fish and Wildlife Research Institute (FWRI, formerly FMRI), and the 2001 *Lake Worth Lagoon Seagrass Survey* by the Palm Beach County Department of Environmental Resource Management (PB DERM). All of these efforts involved photo interpretation of high resolution aerials with little direct groundtruthing in the vicinity of the expansion zones discussed here; however, common trends in habitat distribution over the course of nearly two decades adds validity to the current mapping effort and indicates a long temporal stasis for much of the habitat within the potential impact zones.

The 1990 and 1992 surveys reported a broad coverage of discontinuous grasses throughout much of Zones D, F and G, with a lesser encroachment into Zone C. The more recent 2001 survey delineated habitat boundaries on a much finer scale and indicated a contraction of seagrass habitat toward the southern portions of Zone F and a reduction of seagrasses from the center of Zone G (**Figures 11 and 12**). Our surveys confirmed much of the spatial trends presented in the 2001 survey (PB DERM) with only slight refinements: (1) the patchy seagrass reported for the central region of Zone G was observed to be discontinuous rock rubble with small expanses of turf algae. Both could have led to false returns in the PB DERM photo interpretation. (2) Dense beds of *H. decipiens* were found to occur within the Intracoastal Waterway (ICWW). These resources were not previously reported. (3) Dense patches of *H. decipiens* have returned to the northern stretches of Zone F, both adjacent to the existing turning basin and to the east, and (4) dense beds of *H. johnsonii* now occupy the western portion of Zone C, although this diminutive species frequently eludes aerial analysis and may have been present during past surveys.

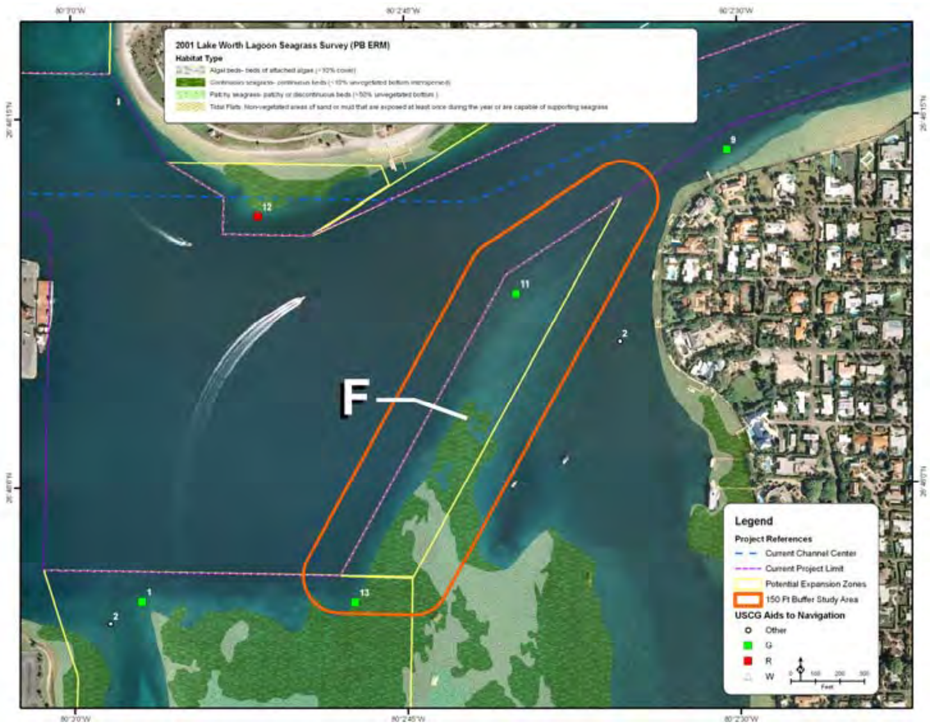


Figure 11. Seagrass habitat delineated in Zone F by the Palm Beach County Department of Environmental Resource Management in 2001.

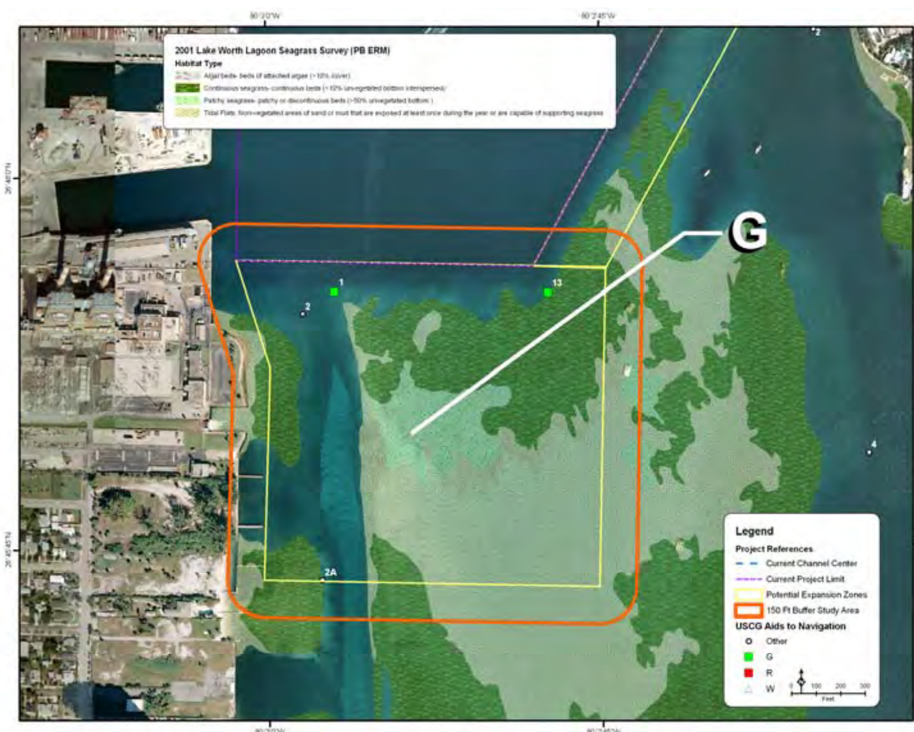


Figure 12. Seagrass habitat delineated in Zone G by the Palm Beach County Department of Environmental Resource Management in 2001.

Overall, the previous work by PB DERM and FWRI agree with the results of the current field evaluation. Differences therein were generally reflective of the methodological limitations imposed by photo-interpreting aerial images and the dynamic nature of *Halophila* spp. both spatially and temporally over even short timeframes. However, when viewed together, these studies make a strong case for the stability of seagrass resources and habitat distribution within the PoPB, despite nearly a decade of heavy commercial and recreational use.

3.2. Hardbottom and Reef Communities

3.2.1. Results

Hardbottom habitat was located and mapped within 5 zones: B-1, B-2, C, D, and G (**Figure 13**). Total hardbottom areal coverage, excluding vertical surfaces, was estimated to be 14.98 acres (60,631.4-m^2). Sum total coverage by zone (number of patches in parentheses) was B-1: 1.43 acres (2); B-2: 3.73 acres (1); C: 9.36 acres (1); D: 0.36 acre (1); and G: 0.10 acre (2). Individual patch sizes ranged from 0.03 to 13.09 acres, where the latter was split across Zones C and B-2 (9.36 and 3.73 acres, respectively). Zones B-1, B-2, and C were selected for further analysis (see below); however, archival video was shot for all identified areas of hardbottom.

Figure 13. Location of hardbottom habitat identified during 2008 by biologists and mapped using DGPS.

Between September and October of 2008, 13 dives were conducted to record downward-facing, handheld video in Zones C (9 dives), B-1 (2 dives) and B-2 (2 dives). Dives were structured so as to cover as much of each zone as was practicable while balancing the safety concerns imposed by tidal and surface traffic conditions (**Figure 2**).

biologists were successful in capturing representative film from each identified subzone within the greater survey area, specifically, the shelf and wall locations discussed previously (Section 2.2.2). A total of 3.68 hours of usable film was shot and archived on Sony DVM60PRL Premium MiniDV 60-minute cassettes in expansion zones C, B-1, and B-2. From this, 1,924 images were extracted with ULead® software and analyzed for percent coverage in CPCe® and later Microsoft Excel (C: N=962; B-1: N=407; B-2: N=555; for a breakdown by subzone please refer to **Figures 14 and 15**). In this manner, a total of 520 linear meters of non-overlapping substrata were quantitatively examined for benthic composition. Approximately 22 minutes of usable film was shot and archived in hardbottom areas of D and G; this video was later qualitatively analyzed for benthic composition.

Recorded taxa included Hydrozoa, Zoanthidea, Porifera, macroalgae, turf algae, coralline algae, seagrasses, and a small percentage of scleractinian coral (**Figures 14 and 15**). Other categories included other live (i.e., echinoderms, fish, crustaceans, ascidians), other (i.e., fish nest, turtle egg debris), sand/shell/detritus, hardbottom, unknown, and debris. A generally low diversity of macrofauna was distinguishable in the still images, particularly when viewed at the functional group level. In all cases, the predominant space occupiers were of suspension and filter-feeding species from Hydrozoa and Porifera. More than 3 species of thecate hydroid (unidentified), and at least 8 species of sponge (*Siphonodictyon* sp., *Agelas* sp., *Niphates* sp., *Amphimedon* sp., *Cliona* sp., *Monanchora* sp., *Ircinia* spp., and *Spirastrella* sp.) were commonly observed during the course of survey.

Mean live bottom coverage varied between 10.9% (C) and 58.1% (BS2) with qualitatively more biota recorded on the vertical (i.e., wall) surfaces relative to adjacent shelf habitats (**Figure 14**). Taxa comprising these differences were typically those of Hydrozoa and Porifera.

Hardbottom in expansion zone D consisted of intermittent rock outcroppings along the ~20-ft. contour of the channel slope. A variety of hydroids, sponges (*Amphimedon* sp., *Niphates* sp., *Ircinia* sp., boring, etc.), and fish (including bandtail pufferfish, sergeant major, juvenile porkfish, and juvenile cocoa damselfish) were observed. *Oculina diffusa* and *Siderastrea* spp. were the only coral taxa found. Hardbottom in expansion zone G consisted of large rock boulders and rock outcroppings. Similar hydroid and sponge taxa observed in expansion zone D were observed in zone G. Observed fish included gray angelfish, juvenile and adult porkfish, grunts, and bandtail pufferfish. Hardbottom photographs captured from handheld video in zones D and G are depicted in **Figure 16**.

	BN1			BN2			BS1			BS2			C			CWALL		
	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N
Hydrozoa	6.22	0.50	370	14.51	1.23	185	0.88	0.21	296	23.34	1.58	111	8.17	0.37	888	14.82	1.51	74
Coral	0.06	0.03	370	0.02	0.02	185	0.38	0.18	296	0.08	0.05	111	0.03	0.01	888	0.11	0.08	74
Zoanthidea	0.00	0.00	370	0.00	0.00	185	2.62	0.84	296	0.00	0.00	111	0.00	0.00	888	0.00	0.00	74
Porifera	3.23	0.55	370	16.04	1.68	185	2.58	0.46	296	34.15	2.34	111	0.85	0.15	888	12.58	2.15	74
Macroalgae	0.43	0.12	370	0.23	0.09	185	0.57	0.15	296	0.00	0.00	111	0.08	0.02	888	0.00	0.00	74
Other Live	0.10	0.05	370	0.19	0.08	185	0.07	0.03	296	0.27	0.11	111	0.17	0.04	888	0.12	0.08	74
Other	0.00	0.00	370	0.00	0.00	185	0.00	0.00	296	0.00	0.00	111	0.00	0.00	888	0.41	0.25	74
Turf Algae	1.10	0.20	370	0.40	0.23	185	5.97	0.70	296	0.23	0.13	111	1.55	0.15	888	0.43	0.24	74
Coralline Algae	0.01	0.01	370	0.00	0.00	185	0.21	0.10	296	0.00	0.00	111	0.00	0.00	888	0.00	0.00	74
Sand Shell Detritus	52.13	1.65	370	36.60	2.40	185	20.71	1.75	296	7.31	1.39	111	57.97	1.17	888	19.70	2.54	74
Hardbottom	36.73	1.53	370	31.98	1.80	185	65.93	1.83	296	34.52	2.38	111	30.91	1.08	888	51.83	3.36	74
Unknowns	0.00	0.00	370	0.00	0.00	185	0.00	0.00	296	0.04	0.04	111	0.00	0.00	888	0.00	0.00	74
Debris	0.00	0.00	370	0.02	0.02	185	0.09	0.06	296	0.08	0.08	111	0.22	0.08	888	0.00	0.00	74
Seagrass	0.00	0.00	370	0.00	0.00	185	0.00	0.00	296	0.00	0.00	111	0.04	0.03	888	0.00	0.00	74
Tape, Wand, Shadow	5.71	0.26	370	5.49	0.46	185	4.31	0.27	296	7.50	0.46	111	6.94	0.19	888	7.73	0.62	74

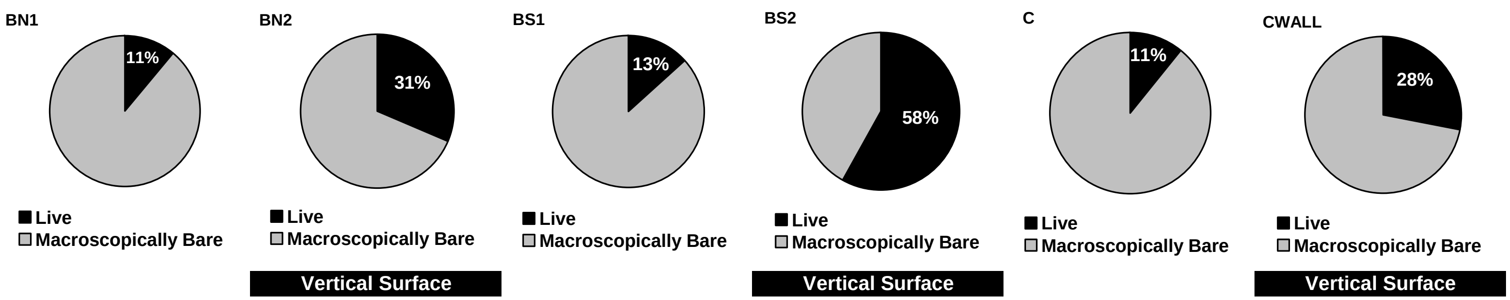


Figure 14. Mean percent cover estimates for the major functional groupings considered during the quantitative, handheld video analysis. Taxonomic groups included in 'Live' cover were Hydrozoa, Coral, Zoanthidae, Porifera, Macroalgae, Turf Algae, Coralline Algae, Seagrass, and Other Live. Subzones representing wall habitat are identified by 'Vertical Surface'

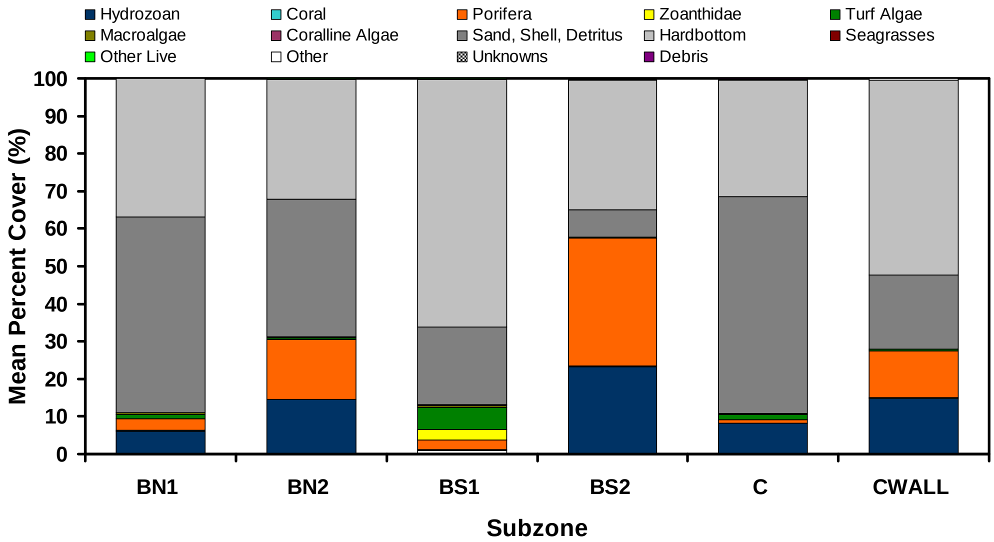


Figure 15. Mean percent cover of benthic constituents observed during the handheld video analysis. Subzone identities were as follows: B-1, BS1 and BS2; B-2, BN1 and BN2; C, C and CWALL.

Figure 16. Hardbottom photographs captured from handheld video in zones D (A-B) and G (C-D).

3.2.2. Distribution

While no significant spatial trends were apparent at the level of zone, several subzone comparisons were made. Most notable among them were the compositional differences found within Zone B-1 (i.e., BS1 v. BS2) and the stark lack of biota found in C proper (**Figure 15**). BS1 was the only subzone to support dense mats of colonial zoanthids, most likely *Palythoa caribaeorum* (Mean+/-SE of 2.62+/-0.84%), driving horizontal surface cover estimates above those of adjacent shelf habitats, roughly 2 percentage points higher than mean values from BN1 and C (13.3%, 11.1% and 10.9%, respectively). BS1 also supported the highest mean turf algal cover with 5.97+/-0.70% and, interestingly, the highest mean coral cover (*Siderastrea* spp. and *Stephanocoenia intersepta*) at 0.38+/-0.18%. The adjacent wall habitat, BS2, yielded the highest overall live bottom coverage with 58.1%, due in part, to the highest mean sponge (34.15+/-2.34%) and hydroid coverage (23.34+/-1.58%). This area also had the lowest recorded mean values for sand, shell, and detritus (collectively, 7.31+/-1.39%). Diver observations at the time of survey indicated that the vertical slope and degree of hardbottom appeared to be greatest on the southern wall of the Inlet (BS2), whilst the northern edge contained substantially more sand (BN2 sand, shell and debris, 36.60+/-2.4%) and descended with a more gradual slope.

This trend was supported by values from CWALL, which was situated to the west of BN2 and also on the northern wall of the inlet. Here, mean sponge and hydroid cover closely resembled those of BN2; however CWALL had considerably less sand, shell or detritus with a mean value of only 19.70+/-2.54%. In contrast, the shelf (horizontal) portions of C exhibited the highest mean values for sand, shell and detritus (57.97+/-1.17%) found anywhere in the survey and supported the only occurrence of seagrasses in the diver video survey. *Halophila johnsonii* comprised 0.04+/-0.03% of C proper.

Factor plots of taxonomic groups by subzone and location maps for each of the 13 handheld video dives are detailed in **Figures 17 - 19**. Note that the dive tracks depicted in the figures are based on straight-line distance from diver entry and exit points and are not necessarily reflective of diver position throughout the course of the dive.

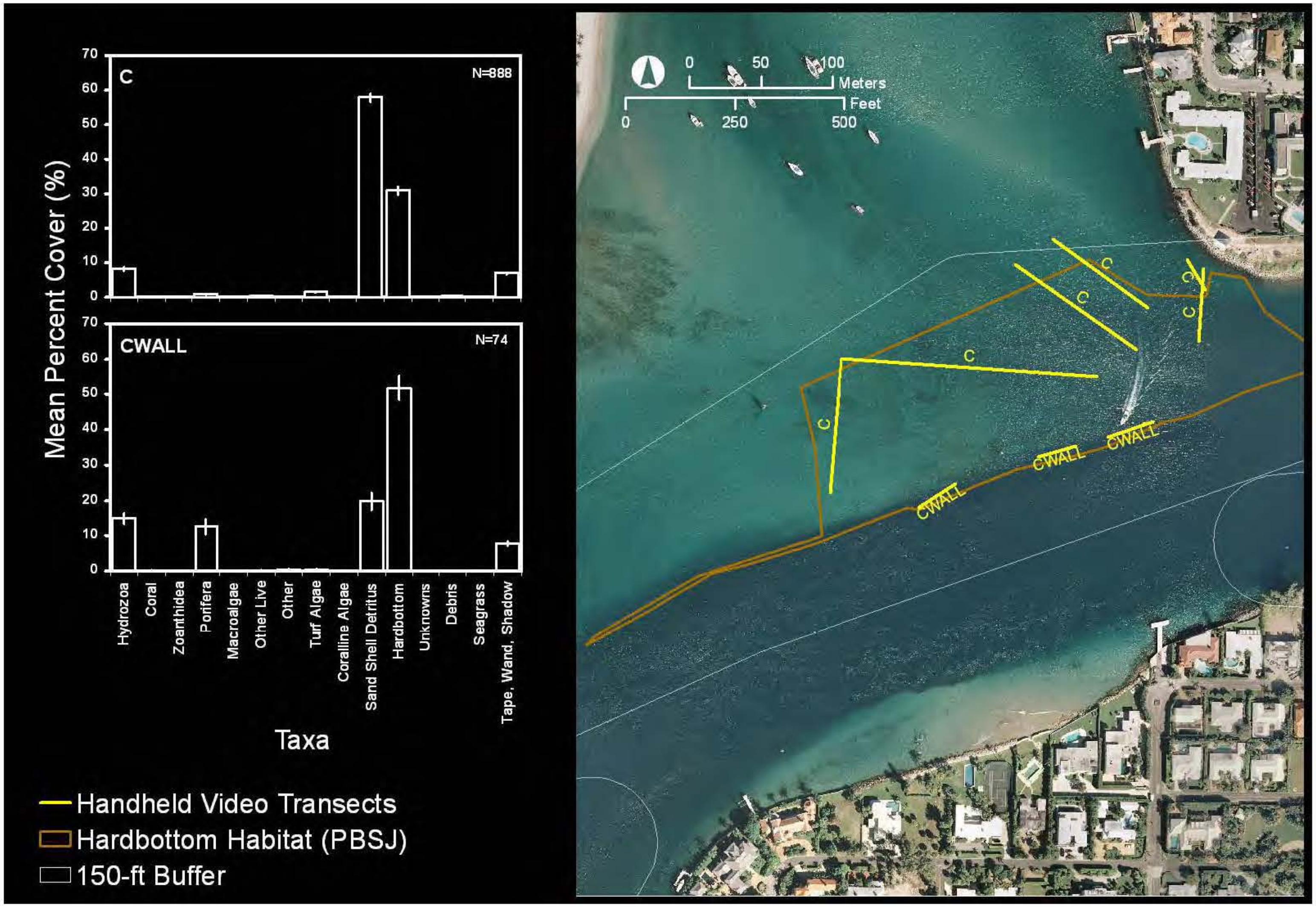


Figure 17. Mean percent coverage of benthic constituents recorded during handheld video analysis of Zone C.

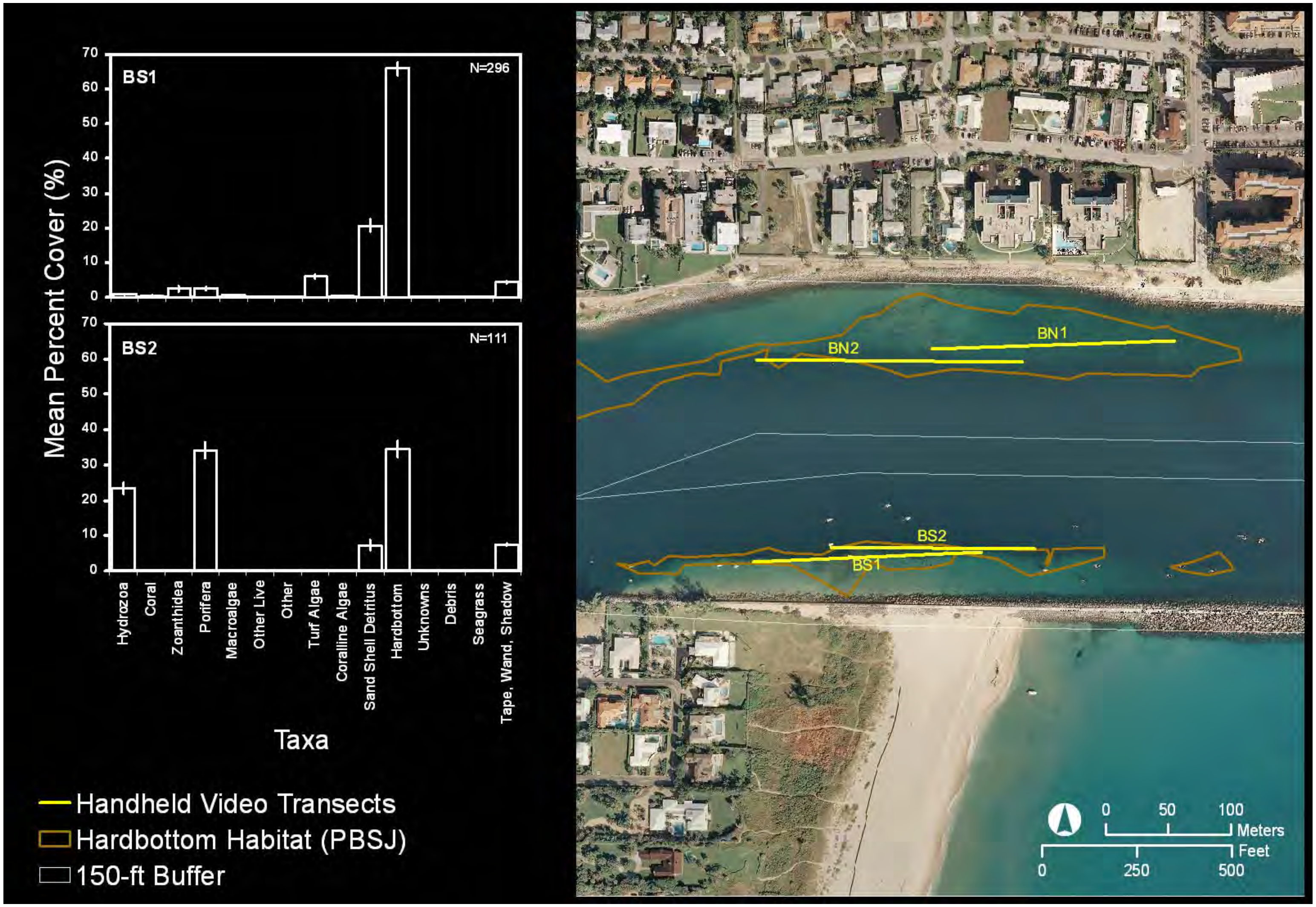


Figure 18. Mean percent coverage of benthic constituents recorded during handheld video analysis of Zone B-1

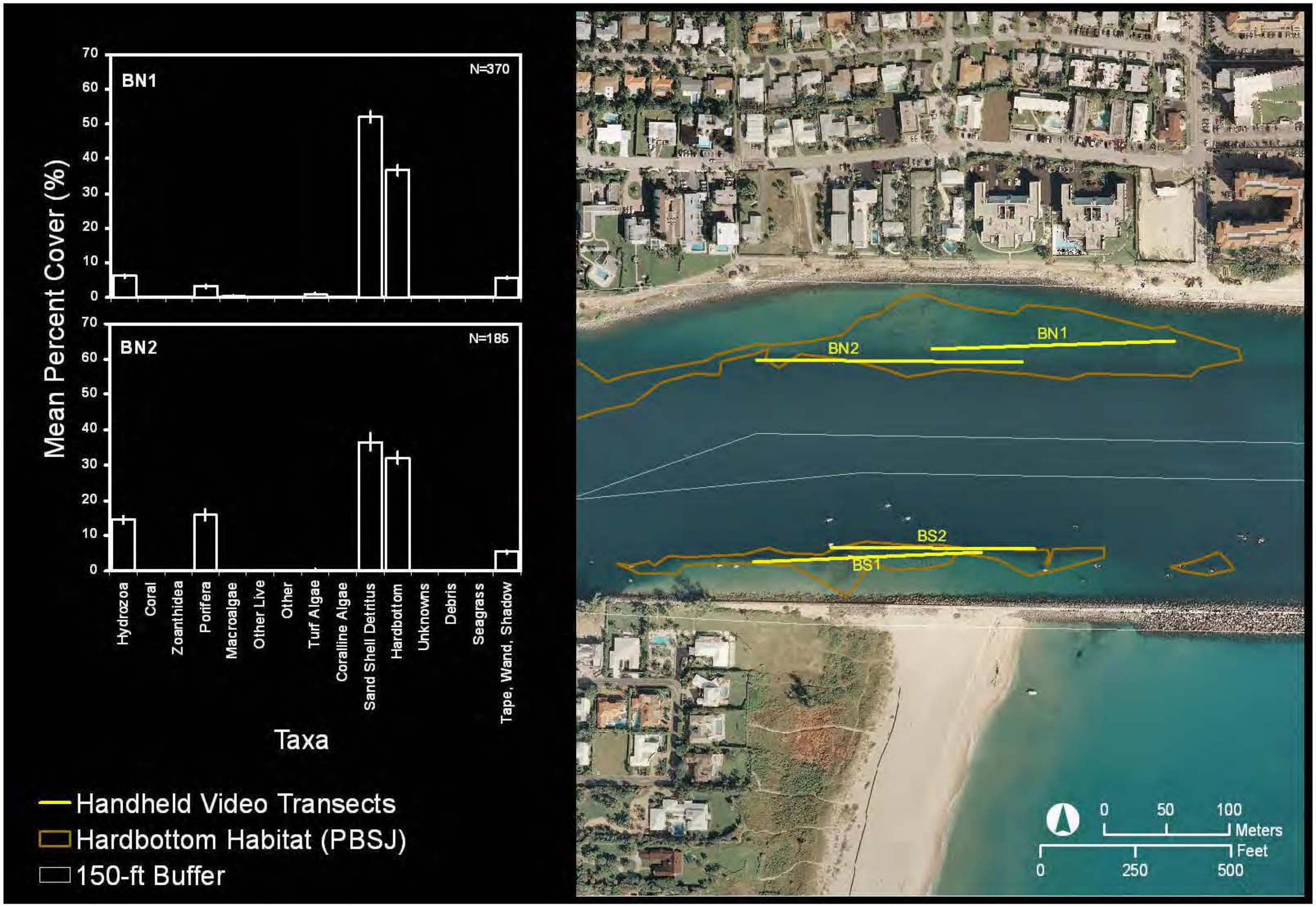


Figure 19. Mean percent coverage of benthic constituents recorded during handheld video analysis of Zone B-2.

3.2.3. Acroporid Survey Results

The *Acropora* spp. surveys were conducted at 8 hardbottom sites in expansion zone A-1 on September 22, 2008. *Acropora* spp. were not found at any of the locations, but see Section 3.3 for further description of the of the habitats within these areas.

3.3. Towed Video Results

Hardbottom habitat and SAV were located and mapped within A-1, A-2, C, the turning basin, the commercial ship channel, and the berths (**Figure 20**). Total hardbottom and SAV coverage (linear meters) were estimated to be 5,441.56-m and 210.93-m, respectively. **Table 4** presents the total coverage of hardbottom and SAV by survey area. Individual hardbottom areas ranged from 0.04- to 498.26-m (both in channel) while individual SAV patches ranged from 0.00- to 40.6-m (channel and C, respectively). It is important to note that the westernmost C-transects, collected in Area D, were not qualitatively analyzed as these areas were previously and thoroughly mapped via SCUBA or snorkel. Also, not all towed video was useable for qualitative analysis. In some instances, increased speed, poor visibility, or increased height off bottom made identification of benthic components difficult.

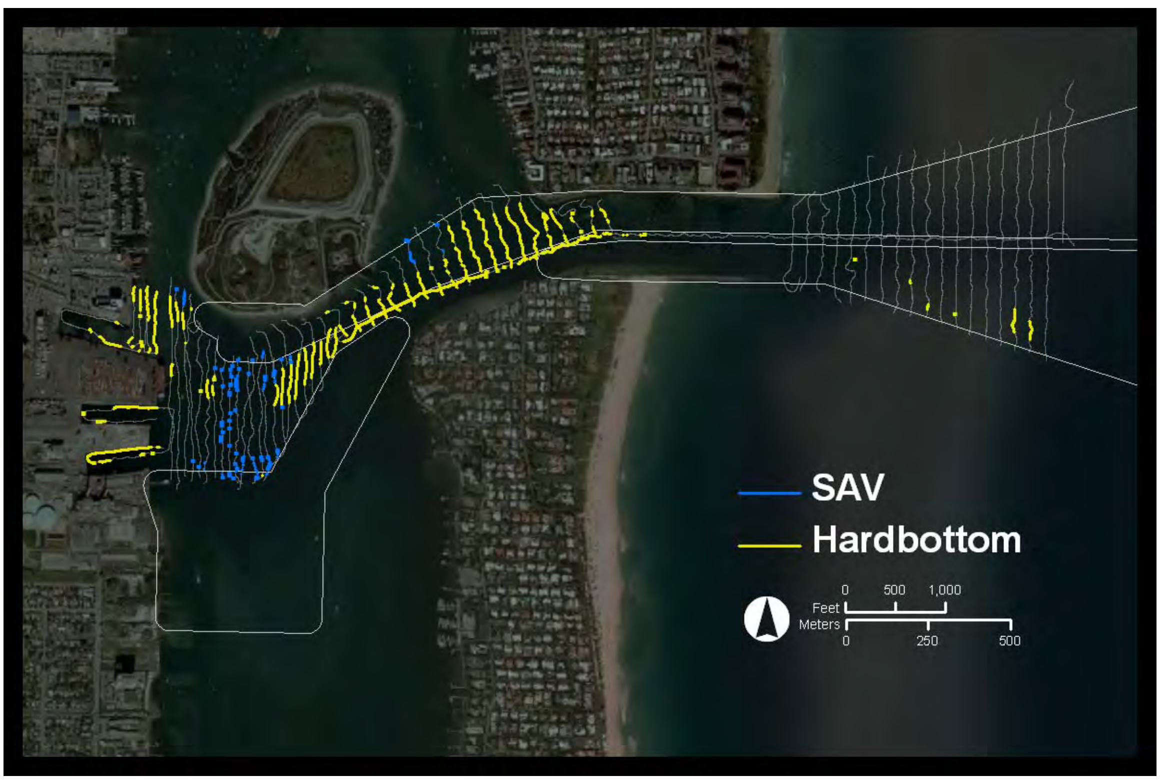


Figure 20. Location of hardbottom habitat and SAV identified from towed video in A-1, A-2, C, the turning basin, the commercial ship channel, and the berths. The yellow points/lines represent hardbottom and the blue points/lines represent SAV. Points indicate single instances of hardbottom/SAV whereas lines represent continuous hardbottom features or SAV.

Table 4. Total hardbottom and SAV coverage (m) observed in survey areas A-1, A-2, C, turning basin, commercial ship channel, and berths. Number of hardbottom areas or SAV patches in parentheses.

Survey Area	Total Hardbottom (m)	Total SAV (m)
A-1	170.08 (4)	0.00
A-2	0.00	0.00
C	1,109.92 (22)	44.53 (2)
Turning Basin	1,761.14 (30)	166.40 (41)
Channel	1,839.46 (37)	0.00
Berths	560.96 (9)	0.00
Total	**5,441.56 (102)**	**210.93 (43)**

3.3.1. Qualitative Analysis of Towed Video

Expansion Zone A

The benthic composition of expansion zones A-1 (south) and A-2 (north) consisted mostly of sediment and shell hash. Six hardbottom areas were identified from the towed video collected in expansion zone A-1. Hardbottom was not observed in A-2. A subset of hardbottom photographs collected in A-1 are presented in **Figure 21**.

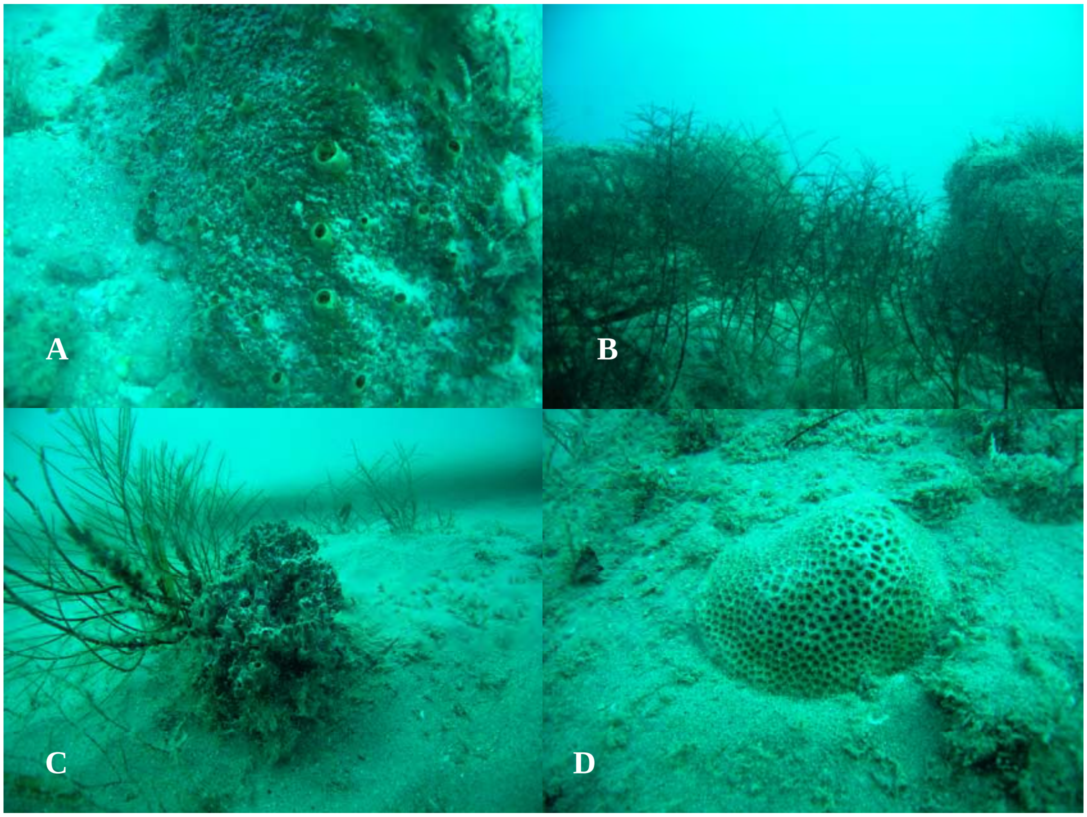


Figure 21. Subset of photographs collected in expansion zone A-1. A) Photograph of Cliona delitrix at site V2. B) Hardbottom community photographed at site 7. Stinging hydroids (Macrorhynchia spp.) located in forefront of photograph. C) Unidentifiable hydroids and lumpy sponge, Monanchora sp., observed at site V4. D) Colony of Siderastrea sp. observed at site V4. E) Variety of hydroid species, a colony of Siderastrea sp., and the white condominium tunicate, Eudistoma sp., at site V4. F) Hardbottom community photographed at site V4. Organisms photographed include the white condominium tunicate (Eudistoma sp.), vase sponge (possibly Niphates sp.), yellow, massive sponge (possibly Aiolochroia sp.), and a variety of hydroids, including the algae hydroid (Thyroscyphus ramosus). G) Large rock boulder with several gorgonians of the Genus Pseudopterogorgia at site V6. H) Rare in Florida, a berried anemone (Alicia mirabilis) photographed at site 7.

Turning Basin

The benthic composition of the turning basin consisted mostly of sediment with sporadic rock rubble, shell hash, and detritus. Organisms observed within the softbottom habitat included hermit crabs, beaded starfish (*Astropecten articulatus*), nine-armed sea star (*Luidia senegalensis*), cushion sea star (*Oreaster reticulates*), and five-toothed sea cucumber (*Actinopygria agassizii*). Debris was frequently observed and included aluminum cans, glass bottles, pieces of metal and cement, and rope.

Softbottom was the major benthic habitat in the turning basin; however, hardbottom and SAV were also observed. Hardbottom was defined as a solid substrate that provides anchorage for sessile or semi-sessile organisms (e.g., corals, gorgonians, sponges, macroalgae, hydroids, etc.). The hardbottom within the turning basin was grouped into 4 areas (**Figure 22**).

Area 1: Patchy hardbottom area located on the northwestern side of the turning basin (west of zone D). Hardbottom characterized by varying amounts of rubble, small to large rocks, and rock boulders colonized by sponges, turf algae, and hydroids **(Figure 23)**. Fish were observed around hardbottom features; however, identification was difficult due to speed and poor visibility.

Area 2: An isolated area of hardbottom located near the center of the turning basin. Hardbottom consisted of small rocks with attached turf algae and hydroids (**Figure 24**). Patches of hardbottom were separated by expanses of sediment, shell hash, and detritus.

Area 3: A single hardbottom point located on the southern boundary of the turning basin. Hardbottom consisted of two concrete blocks (debris) colonized by sponges, hydroids, and turf algae (**Figure 25**).

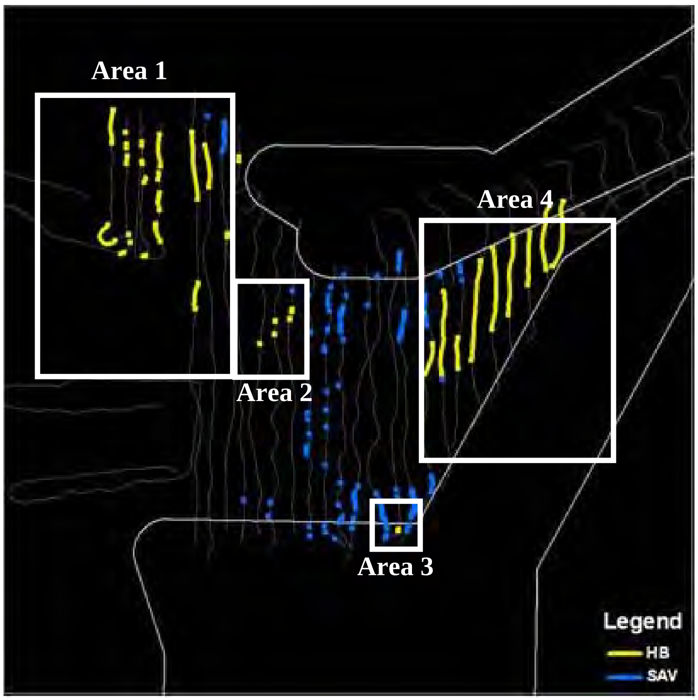


Figure 22. Four areas of hardbottom located in the turning basin.

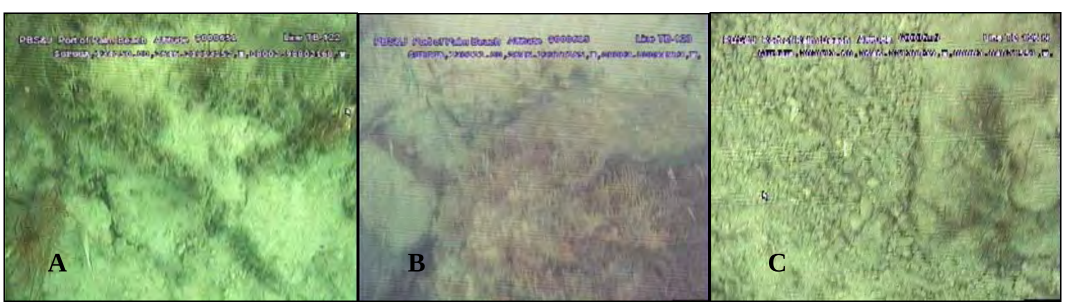


Figure 23. Hardbottom images captured from towed video within Area 1. A) Transect 122: rocks colonized by turf algae, hydroids, sponges, and gorgonians. B) Transect 123: rock boulders colonized by turf algae, hydroids, and sponges. Note fish school below video overlay. C) Transect 126: rock rubble and small rocks colonized by hydroids and turf algae.

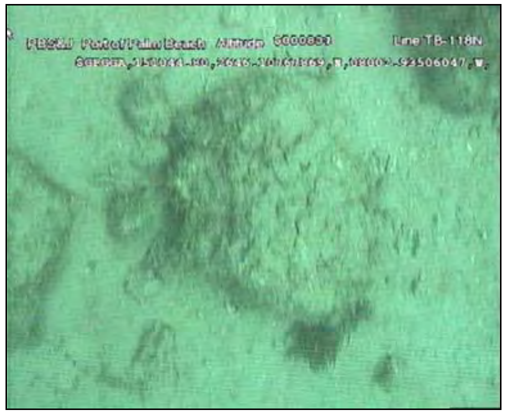


Figure 24. Hardbottom image captured from towed video within Area 2. Transect 118: small rocks with attached turf algae and hydroids.

Figure 25. Hardbottom images captured from towed video within Area 3. Transect 111: two concrete blocks colonized by sponges, hydroids, and turf algae.

Area 4**:** Large hardbottom area located on the northeastern side of the turning basin. Hardbottom characterized by scattered, small to large rocks with attached turf algae, hydroids, and sponges (**Figure 26**).

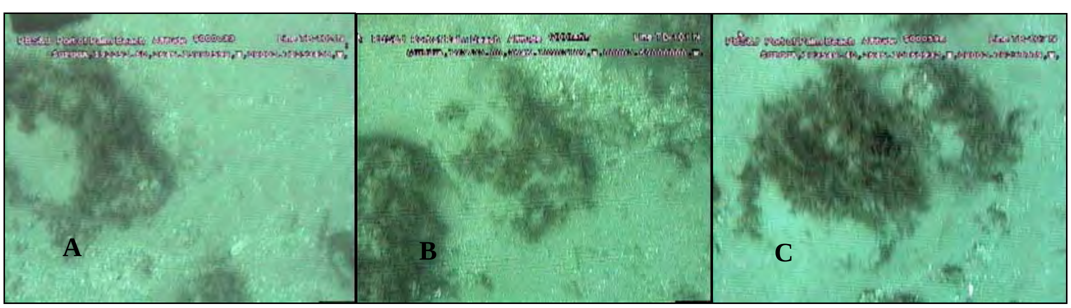


Figure 26. Hardbottom images captured from towed video in Area 4. Small to large rocks colonized by turf algae and hydroids. Photographs captured from transects 102 (A), 101 (B), and 107 (C).

The majority of SAV observed in the turning basin was identified as *Halophila decipiens* (**Figure 27**); however, there were instances when identification was impossible due to increased speed and height off bottom. SAV was located along the central, vertical axis of the turning basin and adjacent to expansion zones D, F, and G. A small patch of SAV was also observed northwest of zone D, just off the west side of Peanut Island.

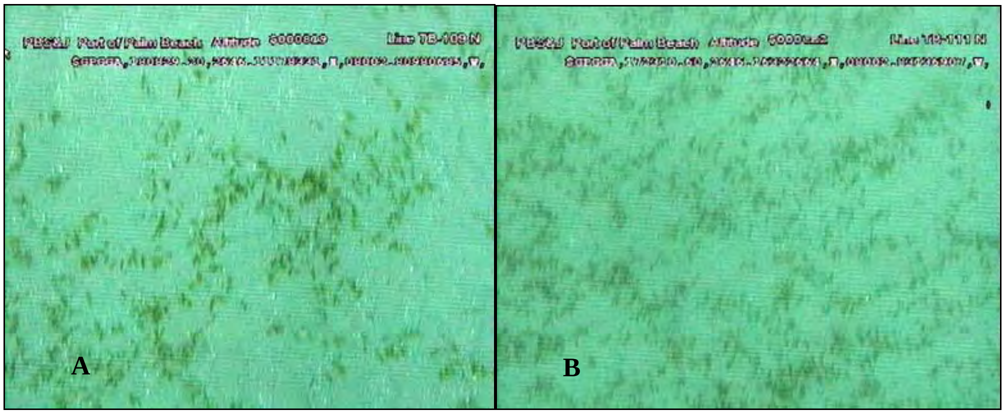


Figure 27. Photographs of Halophila decipiens captured from towed video in turning basin. Photographs from transects 109 (A) and 111 (B).

Channel

A majority of the hardbottom observed in the channel was located adjacent to expansion zone C. In this area, hardbottom consisted of scattered rocks, varying in size from rock cobble to large rock boulders (**Figure 28**). Small rocks were typically colonized by turf algae, hydroids, and the occasional boring sponge. Large rocks and rock boulders were typically colonized by turf algae, hydroids, and sponges. In some instances, a few coral recruits were also observed. Moving eastward from Area C, hardbottom occurrences dramatically decreased (**Figure 20**). Rippled sediment with small amounts of shell hash and drift algae were observed in these areas.

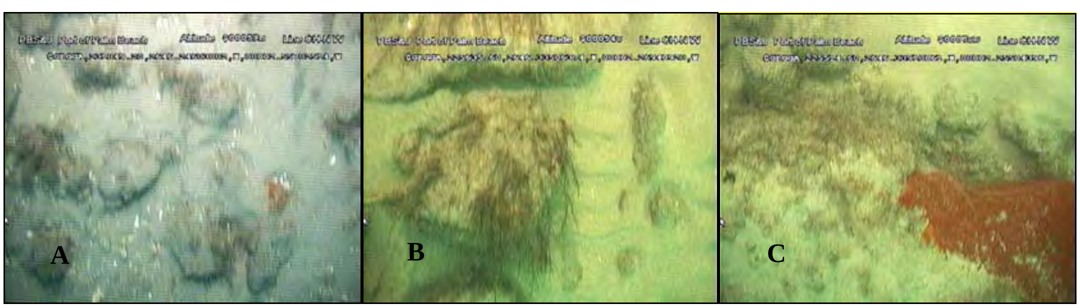


Figure 28. Hardbottom photographs captured from towed video in the channel showing different hardbottom types observed: A) rock cobble, B) small rocks, and C) large rock boulders.

Berths

North Berth: The north berth was mostly sediment with detritus and large amounts of debris. The first hardbottom encountered was an isolated area located on the northeastern side of the berth **(Figure 20**). Hardbottom was characterized by small to medium rocks covered in turf algae, hydroids, and sponges. The second hardbottom observed was located on the interior, south side of the berth and consisted of large, high relief rock boulders colonized by turf algae, hydroids, and a single sponge. The final hardbottom area was larger than the previous two areas and consisted of large rock boulders (colonized by algae, hydroids, and sponges), small to medium rocks (attached turf algae and sponges), and rock rubble. **Figure 29** presents photographs captured from towed video in the north berth.

Middle Berth: The first and largest hardbottom area encountered in the middle berth was located on the northeastern side. Hardbottom in this area was characterized by rock rubble, small rocks with attached turf algae, and large rocks colonized by turf algae, hydroids, sponges, and coral recruits (unidentifiable due to small size, camera speed, and poor visibility). The second hardbottom area was located on the far western side of the middle berth. This isolated hardbottom consisted of rocks with turf algae, hydroids, and sponges. The final hardbottom area observed was located on the southeastern side of the berth and was characterized by scattered, small to large rocks with attached turf algae, hydroids, and sponges. These three hardbottom areas were separated by expanses of fine sediment with detritus and debris. Photographs captured from the towed video in the middle berth are presented in **Figure 30** below.

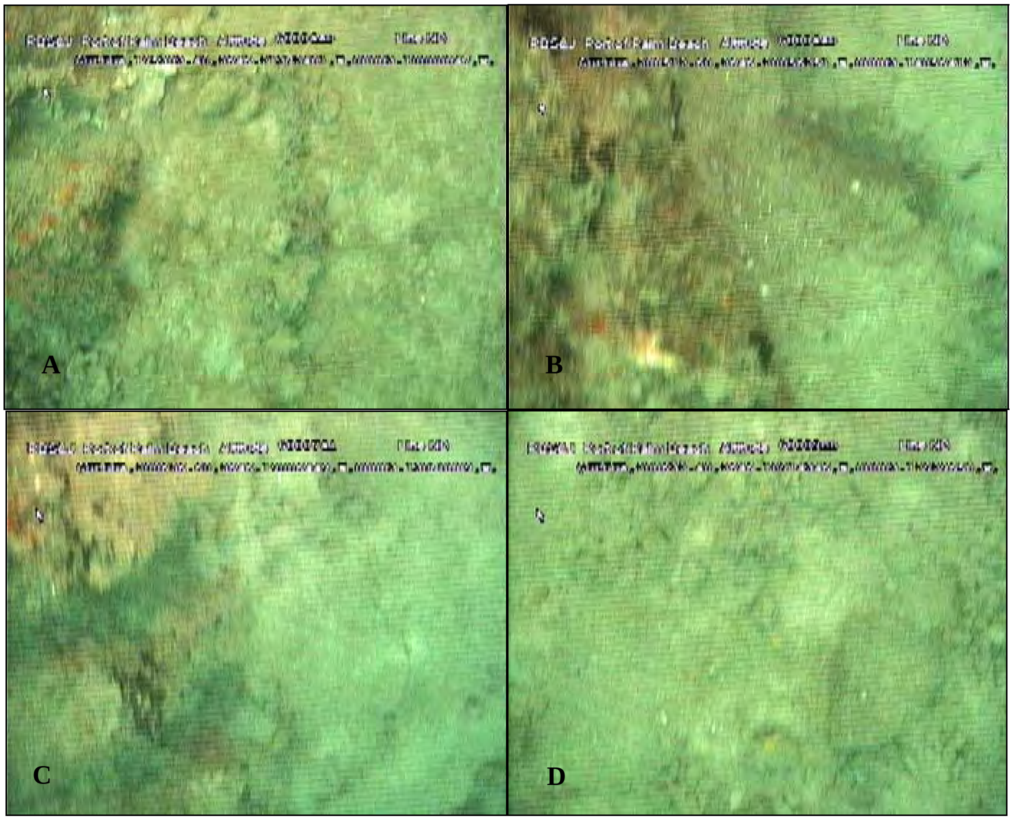


Figure 29. Hardbottom photographs captured from towed video in the north berth. A) First hardbottom encountered with small rocks colonized by turf algae, hydroids, and sponges. B) Second hardbottom area observed with large, high relief rock boulders colonized by turf algae, hydroids, and sponges. Final hardbottom area observed with C) large, high relief rock boulders colonized by sponges and turf algae and D) rock rubble and small rocks with attached turf algae and sponges.

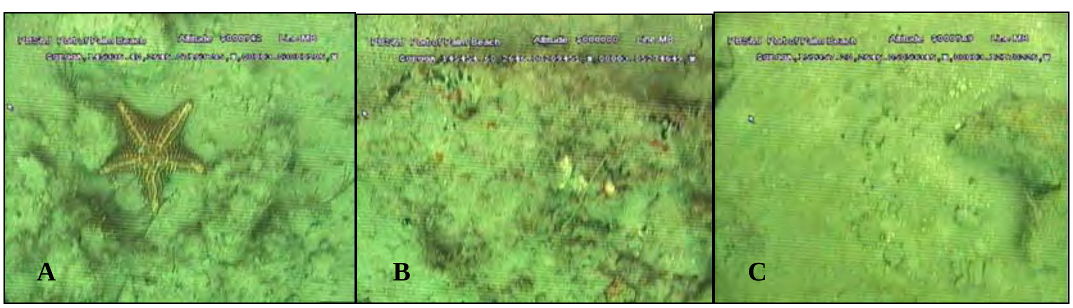


Figure 30. Hardbottom photographs captured from towed video in the middle berth. A) First hardbottom encountered with small rocks colonized by turf algae and hydroids. Cushion sea star (*Oreaster reticulatus*) also in photograph. B) Second hardbottom area observed with large rocks covered by turf algae, sponges, hydroids, etc. C) Final hardbottom area with small rocks colonized by turf algae and encrusting sponge.

South Berth: Consistent hardbottom was observed on the north side of the south berth. Hardbottom was characterized by small to large rocks and rock boulders colonized by turf algae, hydroids, sponges, and few coral recruits (*Siderastrea* sp.). Small, isolated patches of hardbottom were also found along the south side of the berth. These areas contained rock rubble and small rocks with attached turf algae, hydroids, and sponges. Fish, including Haemulidae (grunts) and *Anisotremus virginicus* (porkfish), and debris were also frequently encountered throughout the south berth. Photographs captured from the towed video in the south berth are presented in **Figure 31** below.

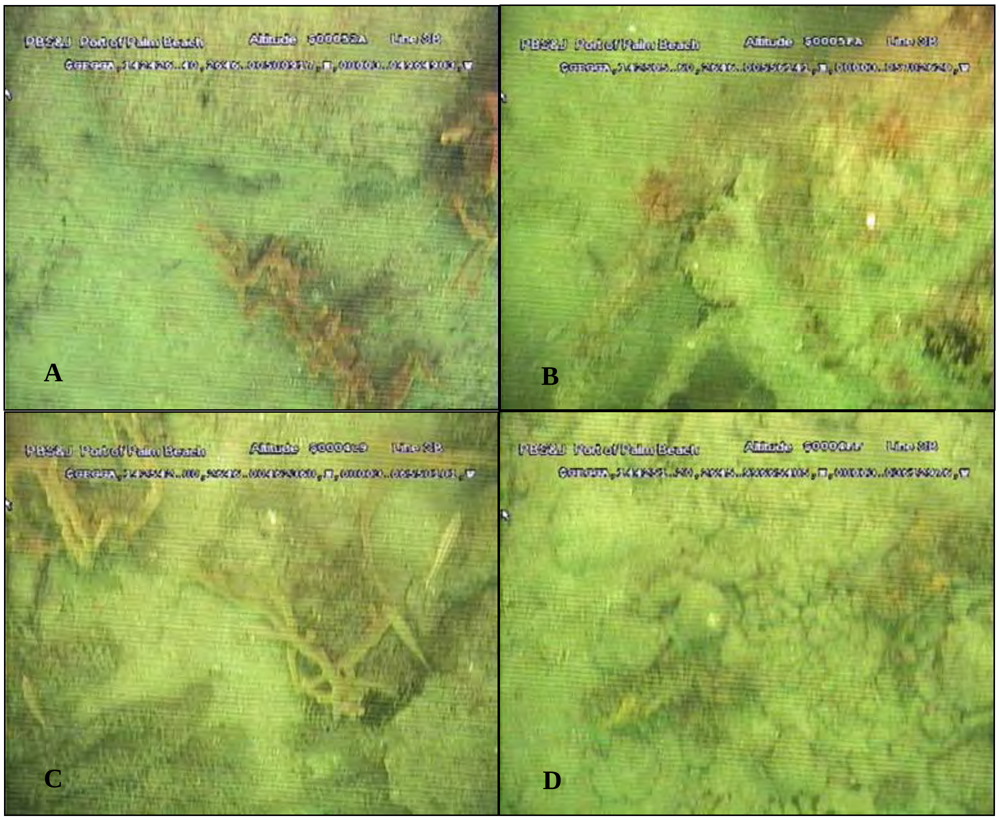


Figure 31. Hardbottom photographs captured from towed video in the south berth. A-C) Photographs captured from the large hardbottom area located on the north side of the south berth. Sponges, hydroids, and turf algae were the major epifaunal groups in this area. Note the debris (fishing net) and fish (Haemulidae) in photograph C. D) Isolated hardbottom on south side of the south berth.

4.0 Summary of Findings

Benthic resources in the vicinity of the PoPB were intensively surveyed by PBS&J biologists during the summer and fall of 2008. All identified habitats were mapped using the latest in GIS technology, documented with archival video and still photography, and quantitatively analyzed for species composition, density, and general trends based on the proposed alternative alignment depicted in **Figure 1.** The following sections represent summary statements, amendable to future Environmental Impact Statement (EIS) documentation, for each of the surveyed zones.

4.1. Zones A-1 and A-2

Benthic substrata within the two off-shore expansion zones were dominated by soft sediments and unconsolidated shell hash. Towed video analysis revealed 6 locations of colonized hardbottom; none were observed to support Acroporid corals. Species that were found included the red boring sponge (*Cliona delitrix*), the pink lumpy sponge (*Monanchora* sp.), massive and lesser starlet corals (*Siderastrea siderea* and *Siderastrea radians*), the white condominium tunicate (*Eudistoma* sp.), a vase-shaped sponge (possibly *Niphates* sp.), a yellow, massive sponge (possibly *Aiolochroia* sp.), a rare, berried anemone (*Alicia mirabilis*) and a variety of thecate hydroids, including the algae hydroid (*Thyroscyphus ramosus*) and others from the genus *Macrorhynchia*.

4.2. Zones B-1 and B-2

Expansion zones B-1 and B-2 included the excavated rock walls of Lake Worth Inlet and short shelf sections extending away from the existing Federal Channel. Hardbottom habitat within these areas tended to be vertically oriented; however, the shelf portion of B-1 did support a measurable percentage of consolidated substrate. Throughout zones B-1 and B-2, the predominant space occupiers were of suspension and filter-feeding species from Hydrozoa and Porifera. At least 3 species of thecate hydroid (unidentified) and 8 species of sponge (*Siphonodictyon* sp., *Agelas* sp., *Niphates* sp., *Amphimedon* sp., *Cliona* sp., *Monanchora* sp., *Ircinia* spp., and *Spirastrella* sp.) typically comprised the benthic assemblage. Few scleractinian coral colonies were documented in either the handheld video or roving diver surveys. Those that were seen were generally *Siderastrea* spp. or *Stephanocoenia intersepta*. No Acroporid corals were observed in either zone.

Species composition, richness and density of benthic invertebrates was similar between Zones B-1 and B-2 with two exceptions: (1) the degree of sand and shell hash retention tended to be higher on the northern face and shelf of the Inlet, resulting in less continuous hardbottom and lower organismal cover, and (2) the southern face and shelf supported the highest coverage of hard corals, turf algae, and the only reported instance of *Palythoa caribaeorum*.

4.3. Zone C

Zone C transitioned (east to west) from colonized hardbottom, similar in species composition to B-2, to the largest extent of *Halophila johnsonii* (Johnsons seagrass) habitat documented in the survey of 2008. Eastern portions of C represented a westward continuation of the same sponge and hydroid communities found on the northern face of the Inlet. *Siphonodictyon* sp., *Agelas* sp., *Niphates* sp., *Amphimedon* sp., *Cliona* sp., *Monanchora* sp., *Ircinia* spp., *Spirastrella* sp., and several species of thecate hydroid were found to dominate the southerly-facing wall and slope regions with diminishing coverage on the shelf and flats to the north. Diver and towed-video surveys also suggested a gradual decrease in hardbottom coverage moving westward through Zone C, with an increasing percentage of sand and shell hash.

The western portion of Zone C supported large monocultures of *Halophila johnsonii*, with an occasional overlap of *Halodule wrightii* (shoal grass). Recorded densities (discussed in Section 3.1.3) and the aerial extent of *H. johnsonii* (Section 3.1.2) in this area indicated it to be a suitable and highly productive habitat for the species.

4.4. Zone D

Hardbottom in expansion Zone D consisted of intermittent rock outcroppings along the ~20-ft contour of the channel slope. A variety of hydroids, sponges (*Amphimedon* sp., *Niphates* sp., *Ircinia* sp., boring, etc.), and fish (including bandtail pufferfish, sergeant major, juvenile porkfish, and juvenile cocoa damselfish) were observed. *Oculina diffusa* and *Siderastrea* spp. were the only coral taxa found.

Seagrass habitat occupied much of the available substrate less than 10-m, particularly south of Peanut Island. Moving up the channel slope, from the 10-m contour shoreward, species composition shifted from monospecific bands of *Halophila decipiens* (paddle grass) to *H. johnsonii*, and finally to a mixed assemblage of *H. johnsonii* and *Halodule wrightii*. However, it should be noted that recorded *H. wrightii* densities within Zone D averaged less than 40% and, qualitatively, appeared much less robust in vegetative growth than other species observed in the Port area.

4.5. Zone F

The tidally scoured, high-flow, sand flats of Zone F supported large expanses of *Halophila decipiens,* interspersed with occasional debris and/or exposed rock outcroppings. *H. decipiens* habitat within the area extended well into the existing turning basin and federal channel down to depths exceeding 10-m. Patch sizes tended to be on the order of 5-m in diameter and were rarely separated by more than 10-m, where present. *H. johnsonii* was reported as infrequent to rare with only 4 instances observed during the percent coverage assessment (Section 3.1.3).

4.6. Zone G

Hardbottom in expansion Zone G was confined to several large rock boulders, particularly on the southern slope of the turning basin, and some small rock outcropping and rock rubble fields in the north central portion of the zone. These habitats supported similar hydroid and sponge taxa observed in Zone D (discussed in Section 4.4). Fish species included gray angelfish, juvenile and adult porkfish, grunts, and bandtail pufferfish.

Seagrasses covered much of the northeastern quadrant as *H. decipiens* habitat extended in a nearly unbroken fashion from Zone F into Zone G in a southeasterly direction. These sand flats gave way to shell hash and rubble fields covered in varying degrees by algal turf. The western half of Zone G supported dense beds of *H. decipiens* to the north with increasing occurrence and density of *H. johnsonii* moving southward past the FPL power plant. A dense bed of *H. johnsonii*, intermixed with *H. wrightii* and *H. decipiens* was documented in the southwest corner of Zone G. These beds were found within the ICW and extended to the edge of the intertidal. Observations of a fruiting event for *H. decipiens* were recorded in this area on August 7, 2008, and indicate the reproductive viability of *H. decipiens* in this area.

The southeastern and far eastern portions of Zone G were revealed by diver survey to contain large fields of migrating sand ripples. Estimated wave heights were roughly 10- cm and consisted of what appeared to be well-sorted sand. These habitats precluded the existence of seagrass and were continuous where found. Due to the high albedo (reflectivity) of this region, it appeared visible in aerial photography and can be seen as a whitened region in **Figure 7** of Section 3.1.1.

5.0 Literature Cited

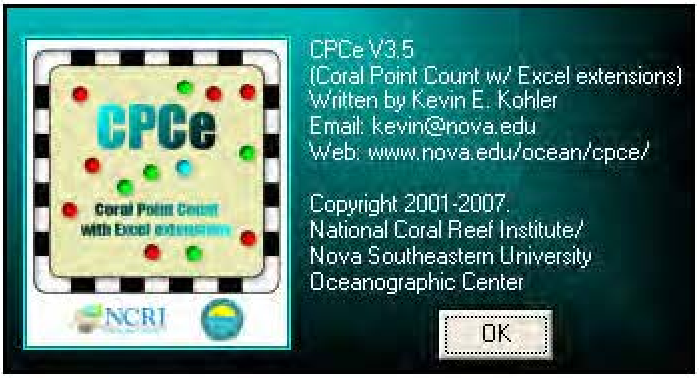
FDEP/SEFCRI 2007

National Marine Fisheries Service. 2002. Recovery Plan for Johnson's Seagrass (*Halophila johnsonii*). Prepared by the Johnson's Seagrass Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland. 134 pages.

Port of Palm Beach. 2009. About the port. Internet website: http://www.portofpalmbeach.com/about_us.htm

Appendix A:

Coral Point Count Extension –
Code File and Major Category Description



Code File

"H","Hydrozoa"
"C","Coral"
"G","Gorgonacea"
"AC","Actiniaria"
"Z","Zoanthidea"
"P","Porifera"
"M","Macroalgae"
"OL","Other live"
"O","Other"
"TA","Turf Algae"
"CA","Coralline Algae"
"SAN","Sand shell detritus"
"HRD","Hardbottom"
"U","Unknowns"
"D","Debris"
"SG","Seagrass"
"TWS","Tape, wand, shadow"
"HY","Hydroids","H"
"CORJU","Unidentified Coral juvenile","C"
"COR","Unidentified coral","C"
"DS","Diploria strigosa","C"
"MC","Montastraea cavernosa","C"
"OD","Oculina diffusa","C"
"SS","Siderastrea sp.","C"
"SB","Solenastrea bournoni","C"
"SINT","Stephanocoenia intersepta","C"
"GORG","Gorgonian","G"
"AGE","Agelas sp.","P"
"AMP","Amphimedon sp.","P"
"APL","Aplysina sp.","P"
"ANT","Anthosigmella varians","P"
"CALY","Callyspongia sp.","P"
"CALX","Calyx sp.","P"
"CIN","Cinachyra sp.","P"
"CLA","Clathria","P"
"CLI","Cliona sp.", "P"
"DIP","Diplastrella sp.","P"
"GEO","Geodia sp.","P"
"HAL","Halisarca sp.","P"
"HOS","Holopsamma sp.","P"
"IOT","Iotrochota birotulata","P"
"IRC","Ircinia sp.","P"
"MON","Monanchora sp.","P"
"MYL","Mycale sp.","P"
"NEO","Neofibularia sp.","P"
"NIP","Niphates sp.","P"
"PHO","Phorbas sp.","P"
"PLA","Plakortis sp.","P"
"PSCR","Pseudoceratina sp.","P"
"RHA","Rhaphidophlus sp.","P"
"SIPH","Siphonodictyon sp.","P"
"SPO","Sponge","P"
"SPH","Spheciospongia sp.","P"
"SPIR","Spirastrella sp.","P"
"STR","Strongylacidon sp.","P"
"TED","Tedania sp.","P"
"ULO","Ulosa sp.","P"
"VER","Verongula sp.","P"
"XES","Xestospongia sp.","P"
"PAL","Palythoa sp.","Z"
"PAR","Parazoanthus sp.","Z"
"ZO","Zoanthid","Z"
"ACT","Actiniaria","AC"
"AST","Asteroidea","OL"
"CHO","Chondrichthyes","OL"
"CRI","Crinoidea","OL"
"CRU","Crustacea","OL"
"ECH","Echinoidea","OL"
"EUD","Eudistoma sp.","OL"
"HOL","Holothuridea","OL"
"OPH","Ophiuroidea","OL"
"OST","Osteichthyes","OL"
"O", "Other","OL"
"TU","Unidentified Tunicate","OL"
"ACE","Acetabularia sp.","M"
"CAU","Caulerpa sp.","M"
"DICT","Dictyota sp.","M"
"HALM","Halimeda sp.","M"
"LOB","Lobophora sp.","M"
"MACA","Macroalgae","M"
"PAD","Padina sp.","M"
"PEN","Penicillus sp.","M"
"RHI","Rhipocephalus sp.","M"
"SAR","Sargassum sp.","M"
"TURF","Turf","TA"
"TURB","Turbinaria sp.","M"
"UDO","Udotea sp.","M"
"CALG","Crustose coralline algae","CA"
"DET","Detritus","SAN"
"SND","Sand","SAN"
"SHM","Shell Material","SAN"
"TB","Fine turf, bare","HRD"
"RR","Rock rubble","HRD"
"DEB","Debris","D"
"UNK","Unknown","U"
"WAND","Wand","TWS"
"SHAD","Shadow","TWS"
"TE","Turtle egg","O"
"FE","Fish nest","O"
"HD","Halophila decipiens","SG"
"HW","Halodule wrightii","SG"
"HJ","Halophila johnsonii","SG"
NOTES,NOTES,NOTES
"ASP", "Aspergillis","NA"
"BL", "Bleached coral point","NA"
"BBD", "Black Band Disease","NA"
"CFB", "Condensed Fish Biting","NA"
"IFB", "Isolated Fish Biting","NA"
"OD", "Other disease","NA"
"P", "Paling","NA"
"PLA", "Plague, Type II (White Plague, Type II)","NA"
"WBD", "White Band Disease","NA"
"YBD", "Yellow Blotch Disease","NA"

Major Category Descriptions

HYDROZOA
Hydroids
CORAL
Diploria strigosa
Montastraea cavernosa
Oculina diffusa
Siderastrea sp.
Solenastrea bournoni
Stephanocoenia intersepta
Unidentified Coral juvenile
Unidentified coral

GORGONACEA
Gorgonian
ACTINIARIA
Actiniaria
ZOANTHIDEA
Palythoa sp.
Parazoanthus sp.
Zoanthid

PORIFERA
Agelas sp.
Amphimedon sp.
Anthosigmella varians
Aplysina sp.
Callyspongia sp.
Calyx sp.
Cinachyra sp.
Clathria
Cliona sp.
Diplastrella sp.
Geodia sp.
Halisarca sp.
Holopsamma sp.
Iotrochota birotulata
Ircinia sp.
Monanchora sp.
Mycale sp.
Neofibularia sp.
Niphates sp.
Phorbas sp.
Plakortis sp.
Pseudoceratina sp.
Rhaphidophlus sp.
Siphonodictyon sp.
Spheciospongia sp.
Spirastrella sp.
Sponge
Strongylacidon sp.
Tedania sp.
Ulosa sp.
Verongula sp.
Xestospongia sp.

MACROALGAE
Acetabularia sp.
Caulerpa sp.
Dictyota sp.
Halimeda sp.
Lobophora sp.
Macroalgae
Padina sp.
Penicillus sp.
Rhipocephalus sp.
Sargassum sp.
Turbinaria sp.
Udotea sp.

OTHER LIVE
Asteroidea
Chondrichthyes
Crinoidea
Crustacea
Echinoidea
Eudistoma sp.
Holothuridea
Ophiuroidea
Osteichthyes
Other
Unidentified Tunicate

OTHER
Fish nest
Turtle egg

TURF ALGAE
Turf

CORALLINE ALGAE
Crustose coralline algae

SAND SHELL DETRITUS
Detritus
Sand
Shell Material

HARDBOTTOM
Fine turf, bare
Rock rubble

UNKNOWNS
Unknown

DEBRIS
Debris
SEAGRASS
Halodule wrightii
Halophila decipiens
Halophila johnsonii

TAPE, WAND, SHADOW
Shadow
Wand

NOTES (% of transect)
Aspergillis
Black Band Disease
Bleached coral point
Condensed Fish Biting
Isolated Fish Biting
Other disease
Paling
Plague, Type II (White Plague, Type II)
White Band Disease
Yellow Blotch Disease

NOTES (% of coral)
Aspergillis
Black Band Disease
Bleached coral point
Condensed Fish Biting
Isolated Fish Biting
Other disease
Paling
Plague, Type II (White Plague, Type II)
White Band Disease
Yellow Blotch Disease

Appendix B:

Percent Coverage
Handheld Video and Seagrass Quadrat Raw Data

Appendix C:

GIS Deliverable

Appendix D: Environmental
Attachment 6: Essential Fish Habitat

LAKE WORTH INLET
Palm Beach Harbor

ATTACHMENT 6: ESSENTIAL FISH HABITAT (AFFECTED ENVIRONMENT)

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) require regional fishery management councils and federal agencies to promote protection, conservation, and enhancement of essential fish habitat (EFH). The EFH provisions of the Magnuson-Stevens Act support one of the Nation's overall marine resource management goals - maintaining sustainable fisheries. Achieving this goal requires maintenance of the quality and quantity of habitats necessary for fishery resources.

The Magnuson-Stevens Act defines EFH as "...those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Rules promulgated by NMFS in 2002 further clarify EFH with the following definitions: **waters** - aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; **substrate** - sediment, hardbottom, structures underlying the waters, and associated biological communities; **necessary** - the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and **spawning, breeding, feeding, or growth to maturity** - stages representing a species' full life cycle. EFH may be a subset of all areas occupied by a species. Acknowledging that the amount of information available for EFH determinations will vary for the different life stages of each species, the rule directs the fishery management councils and the National Marine Fisheries Service (NMFS) to use the best information available, to take a risk averse approach to designations, and to be increasingly specific and narrow in the delineations of EFH as more refined information becomes available.

The rules also provide for fishery management councils and NMFS to consider more limited designations for each species. Habitat Areas of Particular Concern (HAPCs) are subsets of EFH that are rare, particularly susceptible to human-induced degradation, especially important ecologically, or located in an environmentally stressed area. In general, HAPCs include habitats important for the migration, spawning, and rearing of fish or shellfish. Actions with potential adverse impacts to HAPCs are more carefully scrutinized and subject to more stringent conservation recommendations.

The South Atlantic Fishery Management Council (SAFMC) designates mangrove; seagrass; hardbottom, coral, and coral reefs; intertidal flats; coastal inlets; and other bottom habitats within the Lake Worth Inlet project area as EFH (SAFMC 1998). In addition the Mid-Atlantic Fishery Management Council designates coastal inlets as EFH for bluefish and the NMFS designates coastal inlets as EFH for a variety of sharks.

Within southeast Florida, including the Lake Worth Inlet project area, nearshore bottom, live/hardbottom, seagrass, and coastal inlets are HAPCs (SAFMC 1998). Managed species that commonly inhabit the study area include pink shrimp (*Farfantepenaeus duorarum*); spiny lobster (*Panulirus argus*); and members of the 73-species snapper-grouper complex, including blue stripe grunts (*Haemulon sciurus*), yellowtail snapper (*Ocyurus chysurus*), and red grouper (*Epinephelus morio*). These species use inshore habitats as juveniles and sub-adults, and they use hardbottom and reef communities offshore as adults. Other species of the snapper-grouper complex commonly seen offshore in the study area include gray triggerfish (*Balistes capriscus*) and hogfish (*Lachnolaimus maximus*). Coastal migratory pelagic species also commonly utilize the offshore area adjacent to the study area, including cero mackerel (*Scomberomorus regalis*) and Spanish mackerel (*S. maculatus*).

Table 1: Federally Managed Species of Fish that May Occur within the Project Area.

Species	Life Stage	Substrate Preference[1]	
		Unconsolidated Sediment	Seagrass
Brown shrimp *Farfantepenaeus aztecus*	A, J, L	A, J, L	J, L
Pink shrimp *Farfantepenaeus duorarum*	A, J	A, J	J
White Shrimp *Litopenaeus setiferus*	A, J	A, J	J, L
Spiny Lobster *Panulirus argus*	A, J	A, J	A, J
Black seabass *Centropristis striata*	A, J	A, J	
Gag *Mycteroperca microlepis*	A, J	A, J	
Cobia *Rachycentron canadum*	J	J	
Mutton snapper *Lutjanus analis*	A, J	J	J
Gray snapper *Lutjanus griseus*	A, J, L	A, J, L	A, J, L
Lane snapper *Lutjanus synagris*	A, J	A, J	J
Yellowtail snapper *Lutjanus chrysurus*	A, J	J	J
White grunt *Haemulon plumieri*	A, J	A, J	A, J
Sheepshead *Archosargus probatocephalus*	A, J, L	A, J	J, L
Red drum *Sciaenops ocellatus*	A, J, L	A, J, L	J, L
Hogfish *Lachnolaimus maximus*	A, J	J	J
Spanish mackerel *Scomberomorus maculatus*	A, J	A, J	
Black drum *Pogonias cromis*	A, J	A, J	A, J
Southern flounder *Paralichthys lethostigma*	A, J	A, J	J

[1] Substrate preference, unconsolidated sediment and seagrass habitats occur in or near the project area. A=adult; J=juvenile; L=larvae

Table 2: Prey Species that May Occur within the Project Area.

Species	Life Stage	Substrate Preference[2]	
		Unconsolidated Sediment	**Seagrass**
Thinstripe hermit crab *Clibanarius vittatus*	A, J	A, J	
Horse conch *Pleuroploca gigantea*	A, J	A, J	A, J
Bay anchovy *Anchoa mitchilli*	A, J, L	A, J, L	L
Sheepshead minnow *Cyprinodon variegatus*	A, J, L	A, J, L	
Atlantic menhaden *Brevoortia tyrannus*	A, J, L	A	J, L
Bay scallop *Argopecten irradians*	A, J, L	A, J	A, J, L
Atlantic rangia *Rangia cuneata*	A, J, L	A, J, L	
Quahog *Mercenaria mercenaria*	A, J	A, J	
Grass shrimp *Palaemonetes pugio*	A, J		A, J
Striped mullet *Mugil cephalus*	A, J	A, J	A, J
Spot *Leiostomus xanthurus*	A, J	A	J
Atlantic croaker *Micropogonias undulates*	A, J	A, J	
Silversides *Menidia menidia*	A, J, L	A, J, L	A, J, L
American eel *Anguilla rostrata*	A, J, L	J, L	A, J, L

[1] Substrate preference, unconsolidated sediment and seagrass habitats occur in or near the project area.
A=adult; J=juvenile; L=larvae

[2] Substrate preference, unconsolidated sediment and seagrass habitats occur in or near the project area.
A=adult; J=juvenile; L=larvae

SEAGRASS

Review of literature, related information, and views of recognized experts on the habitat or species that may be affected

Community Composition of Seagrass in the Lake Worth Inlet Area

The seagrass community in the Lake Worth Inlet area has included *Halophila decipiens, H. johnsonii,* and *Halodule wrightii*. The seagrass habitats are spatially and temporally dynamic, but persistently present in areas around the turning basin. Seagrass communities were dominated by sparse cover of *H. johnsonii* in single species and mixed beds in shallow to mid-water depth (0-4m), while *H. decipiens* predominated in water depth greater than 4m. *Halodule wrightii* was also found in shallow water, primarily less than 2m. Frequency of occurrence, cover abundance scores, and density were relatively low for all seagrass beds documented. Frequency of occurrence across an entire transect was highest for *H. johnsonii* along Transect 18, with a value of 0.36 out of a possible 1.0. Cover abundance scores for all species, *H. johsonii*, *H. decipiens* and *Halodule wrightii* were less than 26% cover (maximum of 2.33; Table 4) across all transects; which means that seagrasses covered less than 26% of the bottom where they were found. The highest density score, which is the sum of cover abundance scores for a species, divided by the total number of quadrats within a transect, was 0.72.

Regardless of species composition or developmental stage, seagrass patches and entire beds can move, the rate of which may vary on scales of weeks to decades (SAFMC 2009). The expansion and contraction of seagrass beds, also referred to as "pulsating patches" may be a long-term survival strategy of *H. johnsonii* (Virnstein et al. 2009) and other seagrass species. For impact assessment purposes, it is important to consider the broader seagrass habitat and not just the currently vegetated portions. Seagrass habitats include not only continuous vegetated beds, but also patchy environments with unvegetated areas between the patches as part of the habitat (SAFMC 2009). Available data show that patchy habitats provide ecological functions similar to continuous meadows (Murphey and Fonseca 1995). The absence of seagrass in a particular location during an isolated survey event does not necessarily mean that the location is not viable seagrass habitat and could be considered as potential habitat if the environmental conditions are suitable. It could merely mean that the present conditions are unfavorable for growth at that moment in time, and the duration of this condition could vary from months to years (SAFMC 2009).

Virnstein et al. (2006) observed seagrass coverage expansion within a year and concluded that seagrass responds rapidly to changing environmental conditions. Because seagrass coverage and density in the Lake Worth Inlet area is dynamic, this may also indicate high resilience to changing environmental conditions. However, the consequences of human development and other anthropogenic pressures in a coastal basin and the loss of natural hydrologic buffers, can compromise an estuary's resilience to rapidly recover from natural pressures, e.g., hurricanes and seasonal salinity fluctuations (Steward et al. 2006).

Halophila decipiens

H. decipiens had the highest abundance score for all seagrasses within the 2011 study area, but the lowest density. This species is highly fecund and cosmopolitan, occupying niches that larger-sized perennial species cannot utilize (Hammerstrom and Kenworthy 2003). The short life history of *H. decipiens* and the apparent existence of a buried, but moveable seed bank means that spatial organization of this community is dictated by first large-scale dispersal of plant propagules (hundreds of meters) and then, within a growing season, by physical perturbation, bioturbation, and clonal organization of the seagrass operating over very small distances (Fonseca et al. 2008). This species can contribute to a more clumped distribution early in the growing season with subsequent vegetative extension. Fonseca et al. (2008) point out that large-scale disturbance events, such as hurricanes, act to redistribute *H. decipiens* propagules, whereupon clonal organization of the plants in their spring to fall existence likely dictates the pattern of seafloor occupation. Furthermore, bioturbation plays an important role in either burying seeds or bringing seeds to the sediment surface where they can germinate. They further note that this species appears to have the facility for resiliency of natural disturbances (e.g., hurricanes) of its community that appear to be able to move the seed bank hundreds, if not thousands of meters, leading to tremendous seasonal changes in the spatial distribution of the plants. The small seed size and the burial of unvegetated substrate by sediments, coupled with movement along with sediment is a plausible mechanism to explain the inter-annual patterns of seagrass distribution (*sensu* Josselyn et al. 1986). Thus, the definition of "seagrass habitat" for the *Halophila* genera can be highly misleading if presently vacant spaces among patches are not properly considered as requisite space for persistence of the community (*sensu* Fonseca et al. 1998).

Although *H. decipiens* is small and present only through a few months of the year, the species provides significant sediment stabilization (Fonseca 1989). Despite a smaller size and a relatively low rate of production, *H. decipiens* makes an important contribution to primary production in an ecosystem (Iverson and Bittaker 1986). It is important to note that *H. decipiens* communities are a mosaic of seasonally ephemeral seagrass patches that provide the valuable ecological functions recognized for the larger seagrasses (Hammerstrom et al. 2006), therefore the patchy abundance of *Halophila* is a function of the genus dynamics and should be recognized as the ambient condition. Rapid growth, high turnover rates, and labile tissues make *Halophila* spp. a good source of nutrition for several marine herbivores and detritivores (Kenworthy et al. 1989).

Halodule wrightii

Halodule wrightii had the lowest frequency of occurance and abundance of the three seagrasses, but the second highest density. *Halodule wrightii* is a highly productive seagrass under a variety of light, nutrient, and salinity conditions and because of this it is known to have ubiquitous distribution and an opportunistic strategy as a colonizing species (Dunton 1996). This species can persist under diminishing environmental conditions by reclamation of nutrients and stored reserves from senescing shoots and rhizomes (Onuf 1996). Rhizome growth and branch rate for *H. wrightii* is high compared to climax seagrass species (e.g., *Thalassia testudinum*) which allows it to rapidly occupy the space they colonize, however they have a high shoot mortality and low life expectancy which implies they may not occupy the space for long (Gallegos et al. 1994).

Heidelbaugh (1999) conducted a study within a 372 square meter (0.09 acres) study area that examined benthic fauna associated with seagrass and unvegetated bottoms and collected 117 species and 690 macrofaunal organisms from *H. wrightii* beds. The most abundant infaunal organisms belonged to the phylum Nematoda while the most abundant epifaunal species were amphipods and tanaids. The majority of macrofaunal organisms consisted of decapod crustaceans (*Callinectes sapidus*), fishes (*Eucinostomus* sp.), and some gastropods (especially *Bursatella leachii*). An additional study compared nekton densities among *H. engelmannii*, *H. wrightii*, and nonvegetated habitats and, similar to the results of the Heidelbaugh (1999) study, found higher densities in the seagrass habitats (King and Sheridan 2006). These studies and others (Sheridan and Livingston 1983; Stoner 1983; Lewis 1984) conclude that on a per plant biomass basis, *Halodule* provides as much fish and infaunal habitat value as other species with higher above-ground biomass, such as *Thalassia testuninum*.

Halophila johnsonii

Under the Endangered Species Act, the Jacksonville District will separately consult with NMFS on potential effects to threatened *H. johnsonii* from the proposed action, however it is important to note that Johnson's seagrass, like other seagrass species, is also designated as EFH.

Halophila johnsonii was the most frequently occurring seagrass in the 2011 survey, but like all seagrasses, density and abundance was sparse. The expansion and contraction of *H. johnsonii*, also referred to as "pulsating patches" may be a long-term survival strategy (Virnstein et al. 2009). The persistent presence of high density elevated patches of *H. johnsonii* on flood tidal deltas near inlets suggests that it is capable of sediment stabilization (NMFS 2007). Given the similarities between the morphology of other *Halophila* spp*.* and *H. johnsonii,* it is reasonable to assume that *H. johnsonii* has the same capabilities as these other species to provide important ecological functions and services to the coastal ecosystem of southeastern Florida (NMFS 2007).

Ecological Functions of Seagrass and Seagrass as EFH

The SAFMC designated seagrass as EFH for species managed under the snapper-grouper, spiny lobster, and coastal migratory pelagics Fishery Management Plans. See Table 1 for a list of species associated with these seagrass habitat and documented in the project area. Other studies from Florida have reported that young gray snapper are frequently collected by shrimp trawlers in seagrass beds at night (Serafy et al. 2007). Other species managed under the snapper-grouper fishery management plan that show an affinity with seagrass habitat include juvenile dog snapper (*L. jocu*), goliath grouper (*Epinephelus itajara*), bluestripe grunt, spiny lobster, and pink shrimp. Additionally, species managed under the highly migratory species fishery management plan, such as tiger (*Galeocerdo cuvier*) and Atlantic sharpnose (*Rhizoprionodon terraenovae*) sharks have an affinity for seagrass habitats.

Many ecological functions are associated with seagrass, including nutrient recycling, detrital production and export, sediment stabilization, and provision of food and habitat for many life stages of numerous marine species. The most well-known function of seagrass is the role as habitat for numerous fishes and invertebrates. Some species spend their entire lives within seagrass beds and others utilize them only during certain stages of their life cycle (usually the postlarval and juvenile stages). Seagrass beds are one of the primary nursery habitats for coastal marine fauna because of their abundance of prey items as well as the protection they provide from predators. Like many of the larger species, *Halophila* species provide organic matter, habitat structure, and food for benthic feeding organisms (Valentine and Heck 1999). In addition, *Halophila* based ecosystems are important food for herbivorous reptiles (Ross 1985).

Seagrass habitats perform numerous important functions in coastal ecosystems that aid in successful spawning, feeding, and growth of several seasonal and resident fishery species, thus serving as EFH. SAFMC (2009) provides a review of several studies have concluded that, although juvenile fish and shellfish can use other types of habitat, many estuarine species rely on seagrass for either part of their life history or some aspect of their nutrition, and that the loss or reduction of this habitat will produce concomitant declines in juvenile fish settlement. Seagrass habitat type is essential to many species of commercial, recreational and ecologically important shellfish and finfish (SAFMC 2009). *Halophila* based ecosystems, like the habitats within the Lake Worth Inlet project area, are particularity important habitats for penaeid shrimp (Ross 1985). Scientific evidence also indicates other species have a strong reliance on seagrass habitats as well including, blue crabs and spiny lobster (SAFMC 2009).

One of the more important functions of seagrass as EFH is the nursery role. Seagrass habitats serve as nurseries for juvenile fish and their food sources. Seagrass habitats also affect ecological processes which enable fish to grow and mature to different ontogenetic stages, eventually reaching adult forms and emigrating to other habitats (Orth et al. 1984; Koenig and Coleman 1998; Beck et al. 2001). Several studies indicate that juvenile fishes are the most abundant age group in seagrass beds, especially in more temperate waters (SAFMC 2009). In particular, juvenile yellowtail snapper and French grunt are highly associated with seagrass beds (Cocheret de la Moriniere et al. 2002). Seagrass functions as a nursery is critical for many estuarine dependent fishery species in the South Atlantic region such as gag groupers (*Mycteroperca microlepis*), flounders (family Pleuronectidae), red drum (*Sciaenops ocellatus*), weakfish (*Cynoscion regalis*), and striped mullet (*Mugil cephalus*) (Thayer et al. 1984).

The same ecological characteristics of seagrass beds that make the habitat favorable for juveniles should also benefit larval fish and invertebrates. There have been a few studies dealing with larval fish settlement and use of seagrass habitats. Parish (1989) documented that seagrass provides habitat for settling postlarvae and developing juvenile reef fishes. Seagrass beds are important for the brooding of eggs (for example, silverstripe halfbeak, *Hyporhamphus unifasciatus*) and for fishes with demersal eggs (e.g., rough silverside, *Membras martinica*). Larvae of spring-summer spawners such as anchovies (*Anchoa* spp.), gobies, (*Gobiosoma* spp.), pipefish (*Syngnathus fuscus*), weakfish, southern kingfish (*Menticirrhus americanus*), red drum, silver perch (*Bairdiella chrysoura*), rough silverside, feather blenny (*Hypsoblennius hentzi*), and halfbeaks are present and use seagrass beds (SAFMC 2009).

A large proportion of the seasonal residents of seagrass habitats in the South Atlantic region spawn offshore on continental shelves and reefs, enter the estuaries in late winter and early spring and take up residency until fall or until they reach a certain ontogenetic stage when they move to other habitats or offshore to renew this cycle.

In addition, seagrass habitats pass on unique biological, physical and chemical characteristics to water bodies which both directly and indirectly contribute to the necessary attributes of EFH (Zieman 1982; Thayer et al. 1984). Seagrass habitats play an important role as EFH by influencing the environment they grow in as well as adjacent environments. Essentially, seagrass habitat affects flow, velocity, and turbulence, thereby creating an environment favorable to settlement of fish and fish food. Organic and inorganic particles settle into the seagrass beds providing nutrients and food, enriching the environment and enhancing secondary production. In turn, the substrate is stabilized, nutrients are temporarily conserved within the meadows and water quality is improved by the presence of seagrass. These ecological services enhance the environmental conditions favoring high rates of primary and secondary production in support of healthy and abundant fish communities (SAFMC 2009).

SOFTBOTTOM HABITATS AS EFH

Softbottom habitat is the area with unconsolidated sediment that lacks vascular plants (i.e., no seagrass is present, but marcoalgae may be present). Within the interior portions of Lake Worth Inlet, the unconsolidated sediment is usually sand, silty sand with sandy material occurring more commonly in shallow waters and near the inlet and silty sediments occurring in deepwater waters of the turning basin. Although soft bottom habitat lacks visible structural features, many microscopic plants occur at the sediment surface and burrowing animals commonly occur below the surface (Peterson and Peterson 1979, Alongi 1990); the dominant taxa of macroinfauna are usually polychaetes, crustaceans, mollusks, and echinoderms. One of the more interesting features of soft bottom communities is that the species within this habitat can significantly structure the habitat thorough processes, such as bioturbation, enhancing water flow through sediments, and tube building, that affect community as a whole. Similarly, soft bottom habitat provides important ecological services to coastal ecosystems (Peterson and Lubchenco 1997). For example, soft bottom areas serve as a storage reservoir of chemicals and microbes. Intense biogeochemical processing and recycling establish a filter to trap and reprocess watershed-derived natural and human-induced nutrients and toxic substances.

One of the more important services provided by soft bottom habitat is foraging habitat for fishery species and their prey. For example, adult white grunts, which are a federally managed fishery species as well as an important food source for species managed within the snapper-grouper complex, are generalized carnivores that feed mainly on benthic invertebrates (Bowman et al. 2000; Potts and Manooch 2001). The high forage value of soft bottom habitat results from the high concentrations of organic matter transported to and produced on soft bottom and the numerically abundant, diverse invertebrate fauna associated with this habitat. While the forage value of soft bottom habitat can vary greatly with position in the landscape, proximity to physical disturbance (such as dredging and wave scour) and chemical disturbances (such as stormwater runoff and low concentrations of dissolved oxygen) can be overriding factors (Pearson and Rosenberg 1978; Diaz and Rosenberg 1995).

Soft bottom habitat also can provide refuge to smaller organisms, such as juvenile fish, because predators are unable to maneuver effectively in shallow waters. Consequently, juvenile fish typically first recruit to the shallowest portions of an estuary or lagoon. Flounder, rays (e.g., *Urobatis jamaicensis* or *Dasyatis americana*), and small cryptic species, such as pink shrimp and blue crabs, can bury in the sediment, camouflaging themselves from predators. Smaller predators in shallow water and larger predators in deeper water also bury themselves in soft bottom habitats relying upon ambush tactics for feeding (Walsh et al. 1999). Consequently, many fish, crabs, and shrimp in subtidal, soft bottom habitats forage nocturnally (Summerson and Peterson 1984).

The SAFMC designated soft bottoms as EFH for species managed under the snapper-grouper, shrimp, and spiny lobster fishery management plans. Federally managed species documented in the Lake Worth Inlet expansion area and associated with soft bottom habitat include white grunt, pink shrimp, and spiny lobster. Additionally, species managed by NMFS under the highly migratory species fishery management plan, such as Atlantic sharpnose, bonnethead (*Sphyrna tiburo*), and finetooth (*Carcharhinus isodon*) sharks have an affinity for soft bottom habitats. See table 1 for a list of species associated with soft bottom habitat and documented in or near the project area.

LAKE WORTH INLET AS EFH

Tidal inlets are HAPCs because of the unique role they play as migratory corridors connecting ocean and estuarine waters that serve as spawning and nursery areas for shrimp, red drum, mackerels, and other species (Hettler and Chester 1990; Lindeman et al. 2000; Faunce and Serafy 2007).

Movement of larval and juvenile fish and shrimp through inlets can vary greatly between inlets and over time with some species migrating nocturnally, within portions of the tidal stream, phases of the lunar cycle or interaction of these factors (Forward et al. 1999). The major point being that migration through inlets rarely is a passive process and, instead, reflect behaviors of the migrants. While modeling studies conducted for this project and summarized in this Draft EIS conclude that changes in the physical characteristics of Lake Worth Inlet Inlet as a result of dredging will be minor, these studies do not examine the response of fish and other organisms to those changes, and such examinations would be difficult to do. Most larval and juvenile fish that utilize the inlet to access their inshore nurseries respond to a variety of environmental factors once they reach the inlet (Boehlert and Mundy 1988). Dredging of inlets, including their ebb and flood tide shoals, may result in unanticipated changes to the cues used by migrants to the estuary. Species that orient to cues associated with the sea bottom may be affected by a deepened channel. Channel dredging also may change flow of long-shore currents. These currents not only affect the transport of sediments along the beach but also influence the recruitment of early life history stages of fish and invertebrates into the estuary. In short, complex modeling and empirical studies would be needed to examine how fish would respond to the modified inlet.

The SAFMC designated coastal inlets as EFH for species managed under the snapper-grouper and shrimp fishery management plans. Additionally, the Mid-Atlantic Fishery Management Council designated coastal inlets as EFH for the bluefish (*Pomatomus saltatrix*) fishery management plan.

HARDBOTTOM HABITATS AS EFH

Channel Wall, Channel Shelf and Nearshore

Expansion zones B-1 and B-2 included the excavated rock walls of Lake Worth Inlet and short shelf sections extending away from the existing Federal Channel. Hardbottom habitat within these areas tended to be vertically oriented; however, the shelf portion of B-1 did support a measurable percentage of consolidated substrate. Throughout zones B-1 and B-2, the predominant space occupiers were of suspension and filter-feeding species from Hydrozoa and Porifera. At least 3 species of thecate hydroid (unidentified) and 8 species of sponge (*Siphonodictyon* sp., *Agelas* sp., *Niphates* sp., *Amphimedon* sp., *Cliona* sp., *Monanchora* sp., *Ircinia* spp., and *Spirastrella* sp.) typically comprised the benthic assemblage.

Eastern portions of C represented a westward continuation of the same sponge and hydroid communities found on the northern face of the Inlet. *Siphonodictyon* sp., *Agelas* sp., *Niphates* sp., *Amphimedon* sp., *Cliona* sp., *Monanchora* sp., *Ircinia* spp., *Spirastrella* sp., and several species of thecate hydroid were found to dominate the southerly-facing wall and slope regions with diminishing coverage on the shelf and flats to the north. Diver and towed-video surveys also suggested a gradual decrease in hardbottom coverage moving westward through Zone C, with an increasing percentage of sand and shell hash.

Hardbottom in expansion Zone D consisted of intermittent rock outcroppings along the ~20-ft contour of the channel slope. A variety of hydroids, sponges (*Amphimedon* sp., *Niphates* sp., *Ircinia* sp., boring, etc.), and fish (including bandtail pufferfish, sergeant major, juvenile porkfish, and juvenile cocoa damselfish) were observed

Continuous hardbottom, sand with scattered hardbottom and hardbottom ledge habitat included a number of benthic organisms unique to hardbottom habitat which were not found in seagrass habitats. Hardbottom benthic organisms were documented to the lowest taxonomic level and are listed in Table 5. Fish populations associated with hardbottom habitat were also documented (Table 6).

Table 3: List of benthic invertebrates and macroalgae documented along transects.

Common Name	Species Name
Sponge	
Black ball sponge	*Ircinia strobilina*
Orange boring sponge	*Cliona delitrix*
Lumpy overgrowing sponge	*Holopsamma helwegi*
Hard Corals	
Lesser starlet coral	*Siderastrea siderea*
Greater starlet coral	*Siderastrea radians*
Hydroids	
Feather bush hydroids	*Dentitheca dendritica*
Macroalgae	
Geen feather algae	*Caulerpa sertularoides*
Y branched algae	*Dictyota* sp.
Oval Blade algae*	*Caulerpa prolifera*

*Documented in seagrass habitat and hardbottom habitat.

Table 4: Fish species documented within project area.

Fish Common Name	Fish Species
Porkfish	*Anisotremus virgincus*
Gray Angelfish	*Pomacanthus arcuatus*
Stoplight Parrotfish	*Sparisoma viride*
Tomtates	*Haemulon aurolineatum*
Grunts (j)	*Haemulon* (spp.)
Blue tang	*Acanthurus coeruleus*
Bluehead wrasse (j,a)	*Thalassoma bifasciatum*

The relative abundance of benthic organisms to each other and the percent cover of hardbottom benthic organisms along transects is described in Table 7 (DCA 2011). Benthic organisms were identified to the lowest taxonomic level and categorized by functional group for analysis. Values are percent cover averages over the entire transect, so lower values represent less hardbottom habitat along the entire transect. Hard corals were noted along transects, whether or not they fell within $1m^2$ quadrats. A total of five hard corals were documented along all transects surveyed and included *Siderastrea siderea* and *S. radians*. Noteably, no soft corals were documented during this survey.

Table 5: Percent cover of hardbottom constituents including hydroids, sponge, hard coral, macroalgae, tunicates and bare space along each transect where hardbottom was documented. Transect totals add to 100% only if the entire transect consisted of hardbottom.

Transect	Hydroid	Sponge	Hard Coral	Macroalgae	Tunicate	Bare	Total
T14	0	2.3	0	0.5	0.01	2.3	5.11
T15	3.3	3.3	0	0	0	6.6	13.2
T16	4.6	2	0	1.2	0.23	12.8	20.83
T17	0.8	0.8	0	0	0	1.6	3.2
T20	9.4	3.8	0	0	0.38	24.0	37.58
T21	0	6.6	0	0	0	10	16.6
T22	1.6	2	0	0	0	4.4	8
T25	17.0	1.4	0.05	0	0.05	34.1	52.6
T26	16.8	0.66	0.06	1.33	0	33.4	52.25
T27	15.7	3.9	0.04	0	0	71.5	91.14
T28	18.7	0.83	0	0	0	76.3	95.83

LITERATURE CITED

Alongi, D. M. 1990. The ecology of tropical soft-bottom benthic ecosystems. *Oceanography and Marine Biology: An Annual Review* 28: 381-496.

Beck, M.W., Heck, K.L., Able, K.W. Jr., Childers, D.L., Eggleston, D.B. Gillanders, B.L. Halpern, Hays, C.G., Hoshino, K., Minello, T.J., Orth, R.J., Sheridan, P.F., and Weinstein, M.P. 2001. The identification, conservation, and management of estuarine and marine nurseries for fish and invertebrates. *Bioscience* 51: 633-641.

Boehlert, G.W., and Mundy, B.C. 1988. Roles of behavioral and physical factors in larval and juvenile fish recruitment to estuarine nursery areas, *In* M.P. Weinstein [editor] Larval fish and shellfish transport through inlets. American Fisheries Symposium 3. pp 51-67. American Fisheries Society, Bethesda, Md.

Bowman R.E., Stillwell C.E., Michaels W.L. and Grosslein M.D. 2000. Food of Northwest Atlantic fishes and two common species of squid. NOAA's National Marine Fisheries Service, NMFS-NE-155.

Cocheret de la Moriniere, E., Pollux, B.J.A., Nagelkerken, I., and van der Velde, G. 2002. Post-settlement life cycle migration patterns and habitat preference of coral reef fish that use seagrass and mangrove habitats as nurseries. *Estuarine, Coastal and Shelf Science* 55: 309-321.

Dial Cordy and Associates Inc (DCA). 1999. Marine Seagrass Survey of Lake Worth Inlet. Revised Final Report to U.S. Army Corps of Engineers Jacksonville District, Jacksonville, FL 26pp. (Do not have)

DCA. 2001. Environmental Baseline Study and Impact Assessment for Lake Worth Inlet Harbor - Final Report. Prepared for U.S. Army Corps of Engineers, Jacksonville District, Jacksonville, FL. 83pp.

DCA. 2006. Seagrass Mapping and Assessment for Lake Worth Inlet Harbor, Final Report, October 5, 2006. Prepared for U.S. Army Corps of Engineers, Jacksonville District, Jacksonville, FL. 18 pp.

Diaz, R. J. and Rosenberg, R. 1995. Marine benthic hypoxia: A review of its ecological effects and the behavioural responses of benthic macrofauna. *Oceanography and Marine Biology: An Annual Review* 33: 245-303.

Dunton, K.H. 1996. Photosynthetic production and biomass of the subtropical seagrass *Halodule wrightii* along an estuarine gradient. *Estuaries* 19: 436-447.

Faunce, C.H., and Serafy, J.E. 2007. Nearshore habitat use by gray snapper (*Lutjanus griseus*) and bluestripted grunt (*Haemulon sciurus*): environmental gradients and ontogenetic shifts. *Bulletin of Marine Science:* 80: 473-495.

FDEP. 2007. Field Notes Florida Department of Environmental Protection. Field inspection of hardbottom sites in the area of Lake Worth Inlet Expansion in 2006 and 2007. Updated in September 2007.

FDEP. 2008. Lake Worth Inlet Seagrass Verification Survey Maps. 5 pp.

Florida Department of Environmental Protection. 2006. Field inspection of hardbottom sites in the area of Lake Worth Inlet Expansion. Updated in September 2007.

Fonseca, M.S. 1989. Sediment stabilization by *Halophila decipiens* in comparison to other seagrasses. *Estuarine, Coastal and Shelf Science* 29: 501-507.

Fonseca, M.S., Kenworthy, J.W., Griffin, E., Hall, M.O, Finkbeiner, M., and Bell, S.S. 2007. Factors influencing landscape pattern of the seagrass *Halophila decipiens* in an oceanic setting. *Estuarine, Coastal and Shelf Science:* 1-12.

Fonseca, M.S., Kenworthy, W.J., and Thayer, G.W. 1998. Guidelines for the conservation and restoration of seagrass in the United States and adjacent waters. NOAA COP/Decision Analysis Series. 222p.

Forward, Jr., R.B., Reinsel, K.A., Peters, D. S., Tankersley, R. A., Churchill, J. H., Crowder, L. B. Hettler, W. F. Warlen, S. M. and Green, M. D. 1999. Transport of fish larvae through a tilde inlet. *Fisheries Oceanography 8* (Suppl. 2): 153-172.

Gallegos, M.E., Merino, M., Rodriguez, A., Marba, N., and Duarte C. 1994. Growth patterns and demography of pioneer Caribbean seagrass *Halodule wrightii* and *Syringodium filiforme*. *Marine Biology Progress Series* 109: 99-104.

Hammerstrom, K.K., and Kenworthy, J.W. 2003. A new method for estimation of *Halophila decipiens* Ostenfeld seed banks using density separation. *Aquatic Botany* 76: 79-86.

Hammerstrom, K.K., Kenworthy, W.J., Fonseca, M.S., and Whitfield, P.E. 2006. Seed bank, biomass, and productivity of *Halophila decipiens*, a deep water seagrass on the west Florida continental shelf. *Aquatic Botany* 84: 110-120

Heidelbaugh, W.S. 1999. Determination of the ecological role of the seagrass *Halophila johnsonii*; a threatened species in southeast Florida. Ph.D., Florida Institute of Technology, Melbourne, FL, 127 pp.

Hettler, Jr., W.F. and Chester, A.J. 1990. Temporal distribution of ichthyoplankton near Beaufort Inlet, North Carolina. *Marine Ecology Progress Series* 68: 157-168.

Iverson, R.L. and Bittaker, H.F. 1986. Seagrass distribution and abundance in Eastern Gulf of Mexico coastal waters, *Estuarine, Coastal Shelf Science* 22: 577–602.

Josselyn, M., Fonseca, M., and Niesen, T., and Larson, R. 1986. Biomass, production and decomposition of a deep water seagrass, *Halophila decipiens* Ostenf. *Aquatic Botany* 25: 47–61.

Kenworthy, W.J., Currin, C.A., Fonseca, M.S., and Smith, G. 1989. Production, decomposition, and heterotrophic utilization of the seagrass *Halophila decipiens* in a submarine canyon. *Marine Ecology Progress Series* 51: 277-290.

King, S.P., and Sheridan, P. 2006. Nekton of new seagrass habitats colonizing a subsided salt marsh in Galveston Bay, Texas. *Estuaries* 29: 286-296.

Koenig, C.C., and Coleman, F.C. 1998. Absolute abundance and survival of juvenile gag, *Myctoperca microlepis*, in seagrass beds of the N.E. Gulf of Mexico. *Transaction American Fisheries Society* 127(1): 44-55.

Lewis, F.G. 1984. Distribution of macrobenthic crustaceans associated with *Thalassia, Halodule* and bare sand substrata. *Marine Ecology Progress Series* 19: 101-113. (Have a copy)

Lindeman, K.C., R. Pugliese, G.T. Waugh, and J.S. Ault. 2000. Developmental patterns within a multispecies reef fishery: Management applications for essential fish habitats and protected areas. *Bulletin of Marine Science* 66(3): 929-956. (Have a copy)

Murphey, P.L., and Fonseca, M.S. 1995. Role of high and low energy seagrass beds as nursery areas for *Penaeus duorarum* in North Carolina. *Marine Ecology Progress Series*. 121: 91-98.

National Marine Fisheries Service (NMFS). 2007. Endangered Species Act 5-Year Review Johnson's Seagrass. Available on-line: http://www.nmfs.noaa.gov/pr/pdfs/species/johnsonsseagrass_5yearreview.pdf

NMFS. 2009. Amendment 1 to the Consolidated Highly Migratory Species Fishery Management Plan, Chapter 5: Essential Fish Habitat. Available on-line at: http://www.nmfs.noaa.gov/sfa/hms/EFH/Final/FEIS_Amendment_1_Chapter5.pdf

Onuf, C.P. 1996. Seagrass response to long-term light reduction by brown tide in upper Laguna Madra, Texas: distribution and biomass patterns. *Marine Ecology Progress Series* 138: 219-231.

Orth, R.J., Heck, K.L., and van Montifrans, J. 1984. Faunal communities in seagrass beds: A review of the influence of plant structure and prey characteristics on predator-prey relationships. *Estuaries* 7: 339-350.

Parrish, J. D. 1989. Fish communities of interacting shallow-water habitats in tropical oceanic regions. *Marine Ecology Progress Series.* 58: 143–160.

Pearson, T.H., and Rosenberg, R. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology: An Annual* Review 16: 229-311

Peterson, C.H., and Lubchenco, J. 1997. Marine ecosystem services. In G.C. Daily (editor), Nature's Services: Societal Dependence on Natural Ecosystems, pp 177-194. Island Press, Washington, DC.

Peterson, C.H., and Peterson, N.M. 1979. The ecology of intertidal flats of North Carolina: a community profile. US Fish and Wildlife Service Biological Services Program FWS/OBS-79/39. 73 pp.

Potts, J.C., and Manooch, III, C.S. 2001. Differences in the age and growth of white grunt (*Haemulon plumieri*) from North Carolina and South Carolina compared with southeast Florida. *Bulletin of Marine Science* 68: 1-12.

Ross, J.P. 1985. Biology of the green turtle *Chelonia mydas* on an Arabian feeding ground. *Journal of Herpetology* 19: 459-468.

South Atlantic Fishery Management Council (SAFMC). 1998. Final Comprehensive Amendment Addressing Essential Fish Habitat in Fishery Management Plans of the South Atlantic Region. Charleston, SC. 142 pp. Available on-line: http://www.safmc.net/Default.aspx?tabid=80

SAFMC. 2009. Fishery Ecosystem Plan of the South Atlantic Region. Available on-line: www.safmc.net/ecosystem/Home/EcosystemHome/tabid/435/Default.aspx

Serafy, J.E., Valle, M., Faunce, C.H. and Luo, J. 2007. Species-specific patterns of fish abundance and size along a subtropical mangrove shoreline: an application of the delta approach. *Bulletin of Marine Science* 80(3): 609-624.

Sheridan, P.F., and R.J. Livingston. 1983. Epifauna inhabiting a *Halodule wrightii* meadow in Apalachicola Bay, Florida. *Estuaries* 6(4): 407-419. (Have a copy)

Smantz, A.M. 1989. Reproductive ecology of Caribbean corals. *Coral Reefs* 5: 43-54.

Steward, J.S., Virnstein, R.W., Lasi, M.A., Morris, L.J., Miller, J.D., Hall, L.M., and Tweedale, W.A. 2006. The impacts of the 2004 hurricanes on hydrology, water quality, and seagrass in the Central Indian River Lagoon. *Estuaries and Coast* 29(6): 954-965.

Stoner, A.W. 1983. Distributional ecology of amphipods and tanaidaceans associated with three sea grass species. *Journal of Crustacean Biology* 3(4): 505-518. (Have a copy)

Summerson, H.C. and Peterson, C.H. 1984. Role of predation in organizing benthic communities of a temperate-zone seagrass bed. *Marine Ecology Progress Series* 15: 63-77.

Thayer, G.W., Fonseca, M.S., and Kenworthy, W.J. 1997. Ecological value of seagrasses: a brief summary for the ASMFC Habitat Committee's SAV subcommittee. Pp. 5–10 *in* Stephan, C.D. and T. E.Bigford (eds.), *Atlantic Coastal Submerged Aquatic Vegetation: A Review of its Ecological Role, Anthropogenic Impacts, State Regulation and Value to Atlantic Coastal Fisheries.* ASMFC Habitat Management Series, No. 1. Atlantic States Marine Fisheries Commission, Washington, D.C. Available on-line at: http://www.asmfc.org/

Thayer, G.W., Bjorgo, K.A., Ogden, J.C., Williams, S.L., and Zieman, J.C. 1984. Role of larger herbivores in seagrass communities. *Estuaries* 7: 351-376.

Valentine, J.F., and Heck, J.L. 1999. Seagrass herbivory, evidence fotr the continued grazing of marine grasses. *Marine Ecology Progress Series* 176: 291-302.

Virnstein, R.W., Hayek, L.C., and Morris, L.J. 2009. Pulsating Patches: A model for the spatial and temporal dynamics of the threatened seagrass species *Halophila johnsonii*. Marine Ecology Progress Series 385: 97-109.

Virnstein, R.W., Steward, J.S., and Morris, L.J. 2006. Seagrass coverage trends in the Indian River Lagoon System. 25th Anniversary Inidan River Lagoon Symposium. 6 pp.

Walsh, H.J., Peters, D.S. and Cyrus, D.P. 1999. Habitat utilization by small flatfishes in a North Carolina estuary. *Estuaries* 22: 803-813.

Zieman, J.C. 1982. The ecology of the seagrasses of south Florida: a community profile. FWS/OBS-82/25. U.S. Fish and Wildlife Services, Washington, D.C. 158 pp. [cited in DCA 2001, so no need to send to CESAJ]